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U.S.A.: 80 cents
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Denmark: Cr. 5.-
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Beyond the Speed of Sound

VOLUME XII 1 JANUARY 1957

A SEVEN-JET B-47?

In this case, yes. The seventh jet, in the rear fuselage pod-mounting shown above, will be Orenda's Iroquois, designed for supersonic speeds.

The Boeing B-47 is on loan from the United States Air Force for flight testing the Iroquois in the initial subsonic phases.

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INTERAVIA

Review of World Aviation

Volume XII **No. 1** **January 1957**

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The Fairey FD.2 research aircraft holds the official world speed record of 1,132 m.p.h.

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OFFICES: Paris: Georges Février (Manager); **London:** Derek Wood (Manager); **Rome:** Giorgio Lourier (Manager); **Frankfurt:** Wolf Eberhard (Manager); **Washington:** Harry Tennant (Editorial Director U.S.A.).

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Interavia U.S.A. 185 Madison Ave., New York 16, N.Y.
803 National Press Building, Washington D.C.

Distributors:

Austria Morawa & Co., Wollzeile 11, Vienna I
Canada Wm. Dawson Subscription Service Ltd., 587 Mount Pleasant Road, Toronto, 12, Ont.
Edward Company Regd., P.O. Box 98, Station Delorimier, Montreal P.Q.
Finland Akateeminen Kirjakauppa, Keskuskatu 2, Helsinki
Rautatiekirjakauppa Oy, Köjdenpunojank 2, Helsinki
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Advertising Department: Publishing and Editorial Offices, Subscription Department: Interavia S.A., 6, Corraterie, Geneva. Telephone: 25 42 34 (five lines). Cables and Telegrams: Interavia-Geneva. Teleprinter: 2 21 22. Postal Cheque Account: Geneva I 5380.

Annual Subscriptions: U.S.A. and Canada, U.S. $7.00; United Kingdom and Eire, £1.15.0; Commonwealth, £2.6.0; Switzerland, 28.— fr.; Austria, 170.— sch.; Belgium, 320.— fr.; Denmark, 48.— kr.; France, 2400.— fr.; Germany, 27.50 DM; Holland, 25.— fl.; Italy, 4060.— L. it.; Japan, U.S. $7.00; Latin American countries, U.S. $7.00; Norway, 50.— kr.; Spain, 280.— pts.; Sweden, 35.— kr. All other countries, 28.— Sw.fr.

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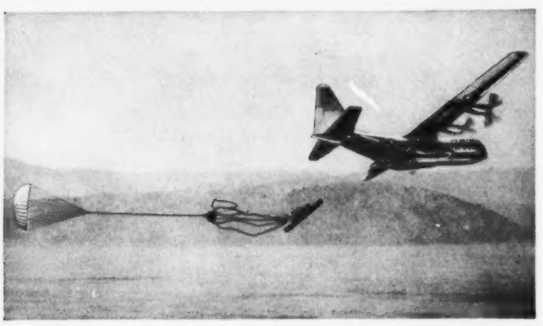

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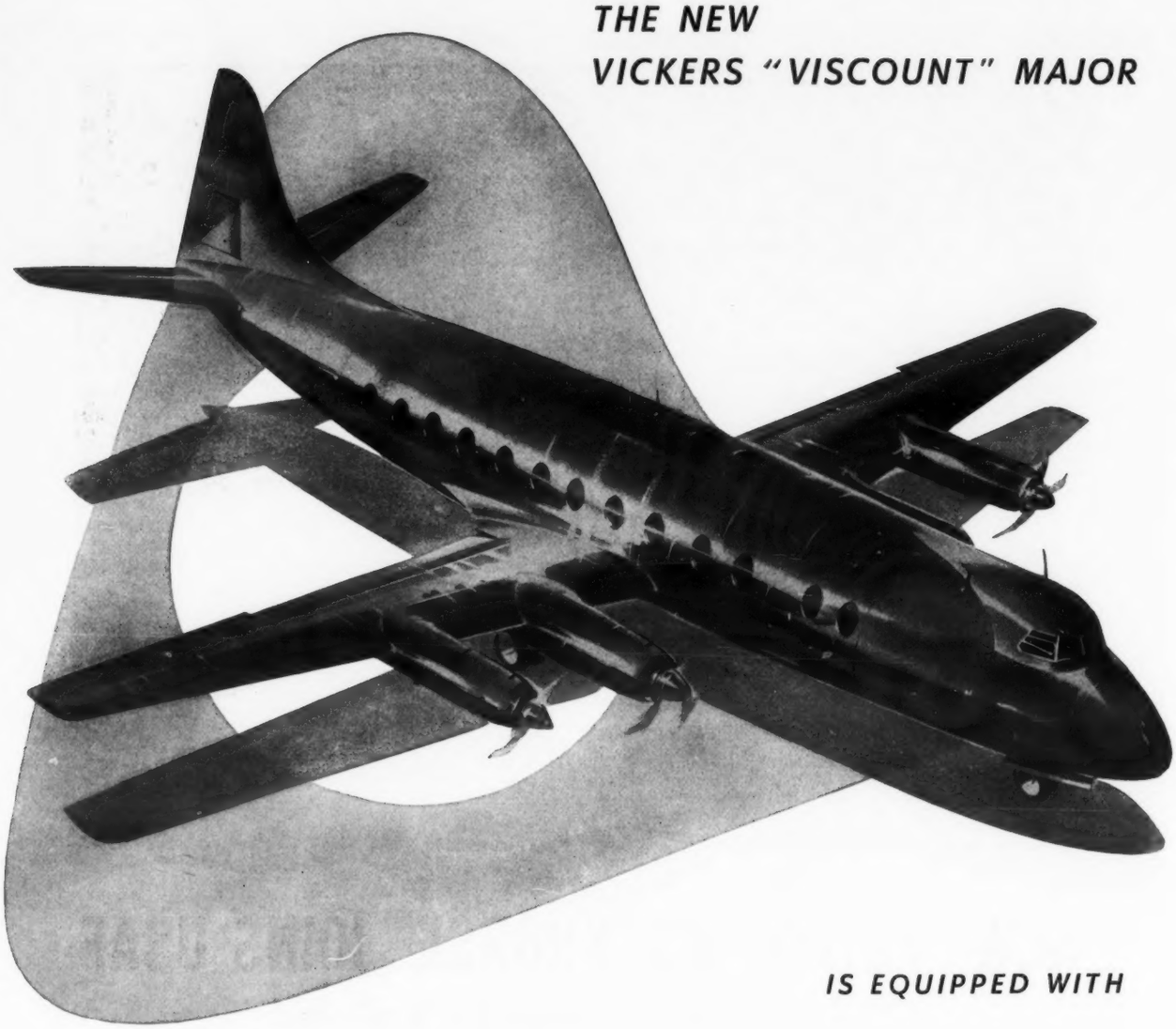

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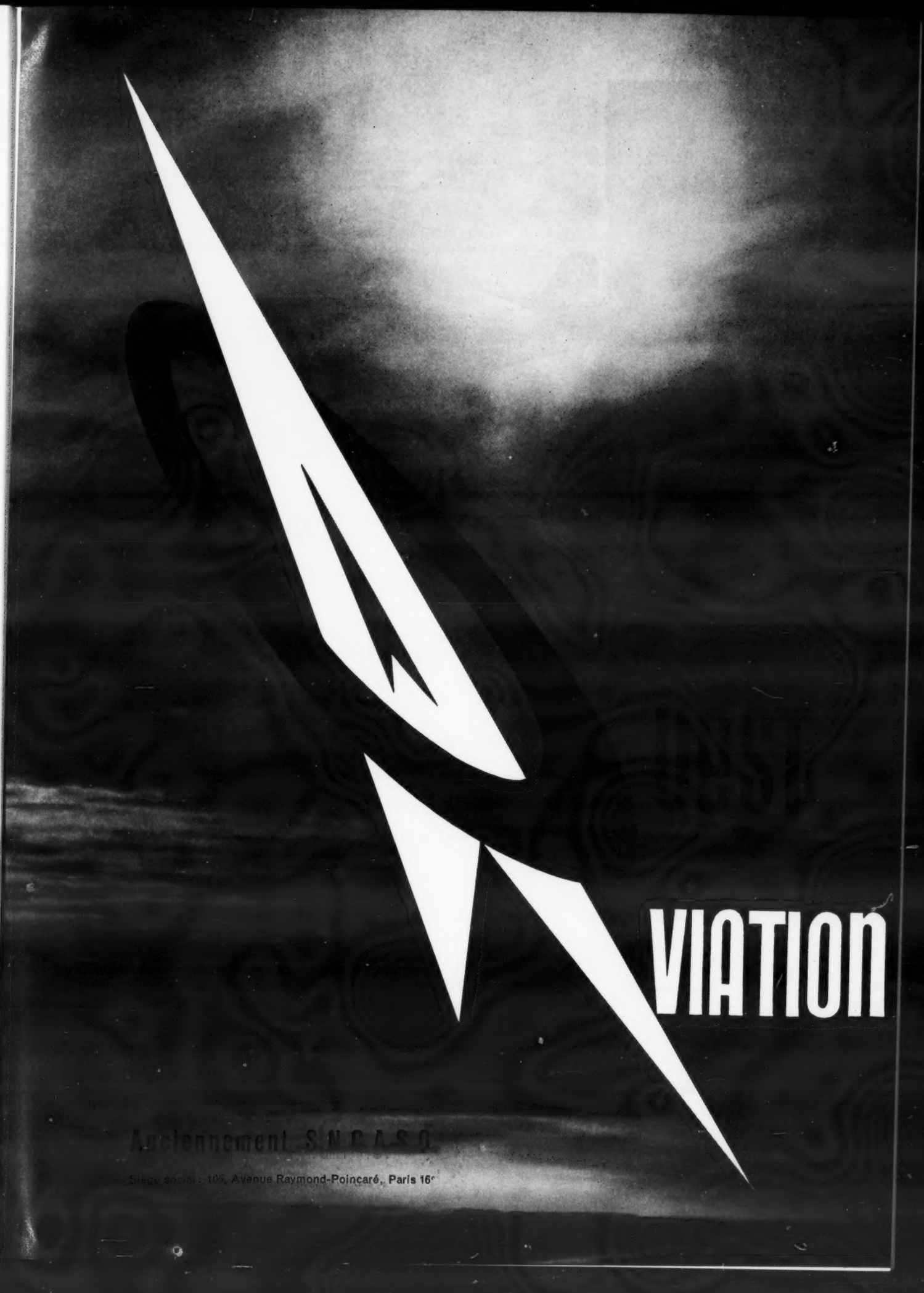
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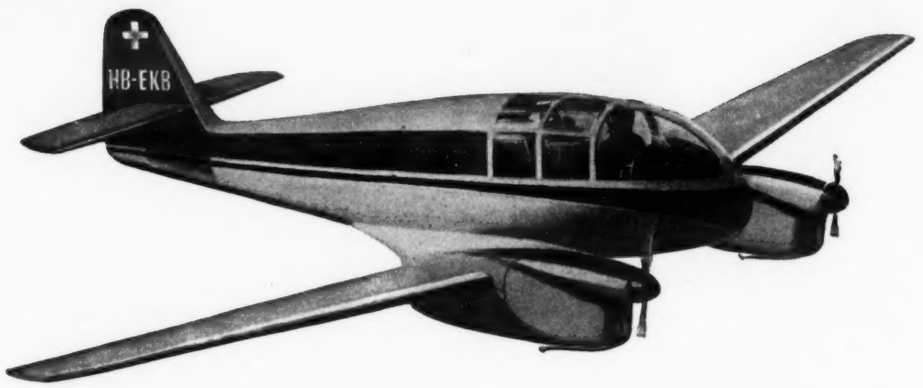

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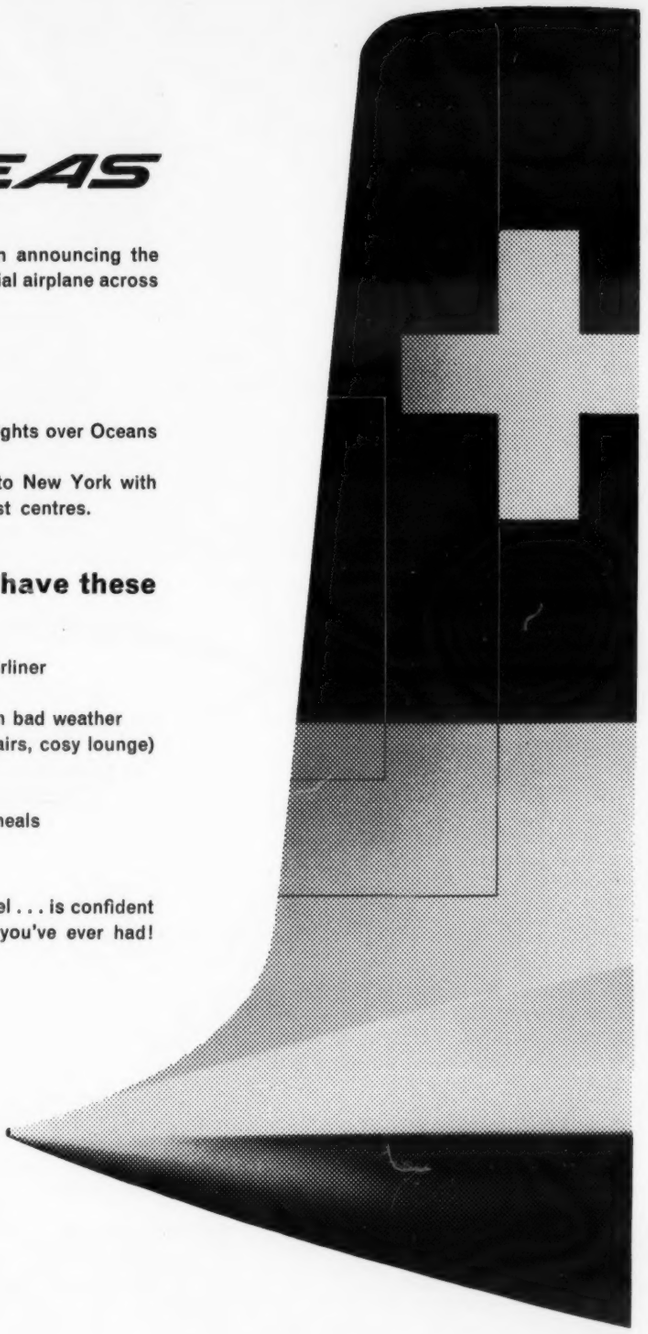

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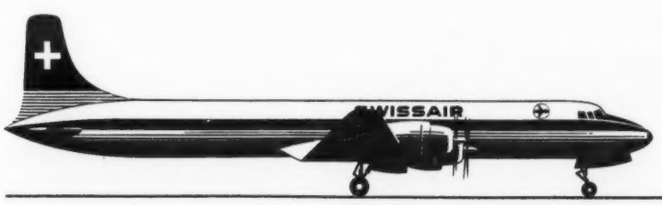

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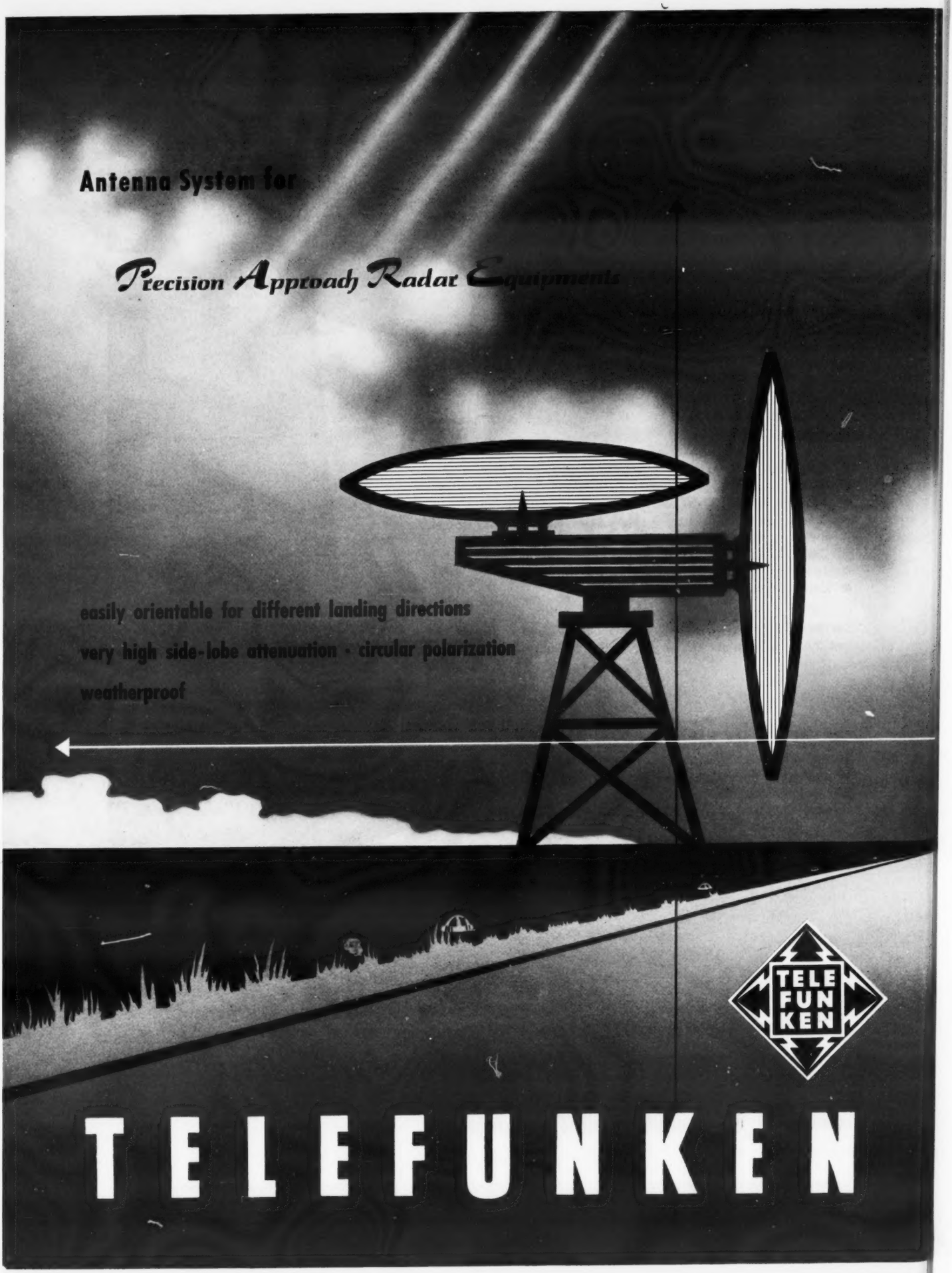
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From studies made of the published direct operating costs (including depreciation) of a number of typical airlines, it is proved that in the light of our guarantees a converted aircraft will be cheaper to operate—whether the costs are calculated on the basis of aircraft miles, ton miles or passenger miles. The ELAND-engined Convair 340 can carry its maximum payload 930 miles further than piston-engined Convairs, and its cruising speed is 50 m.p.h. higher.

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Three examples of successful Napier Eland conversions: the Convair 340, the Elizabethan, the Varsity

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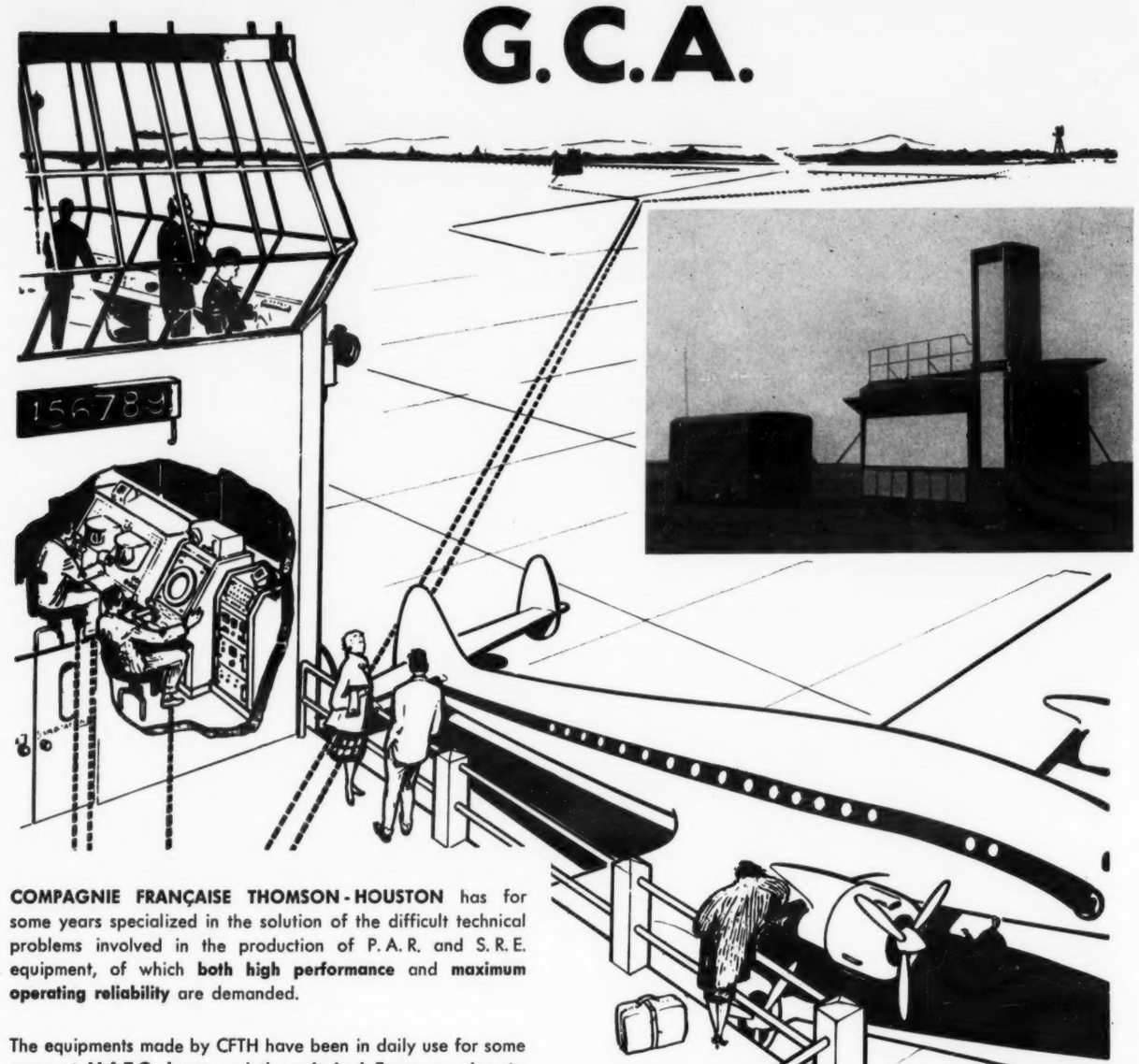

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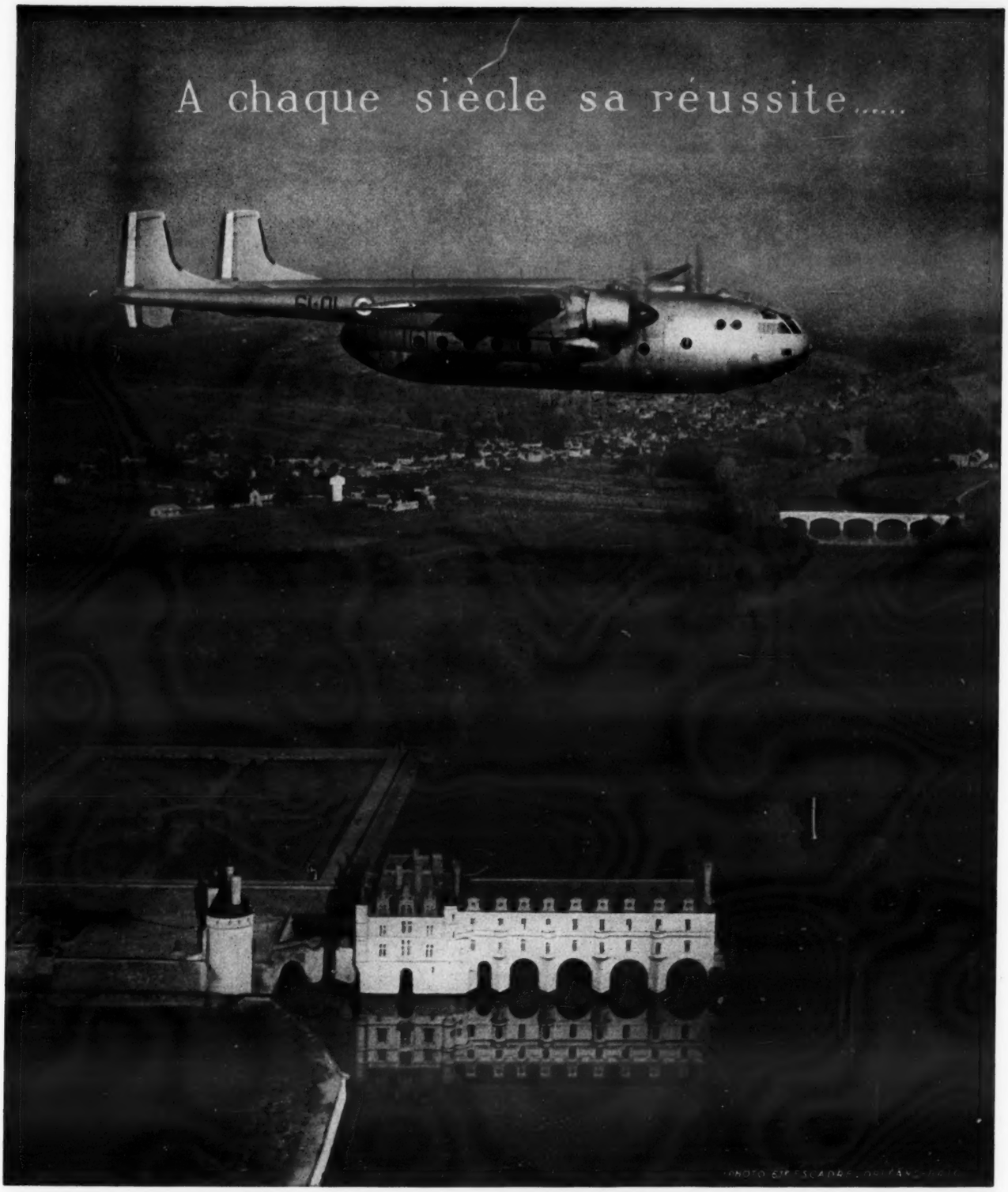

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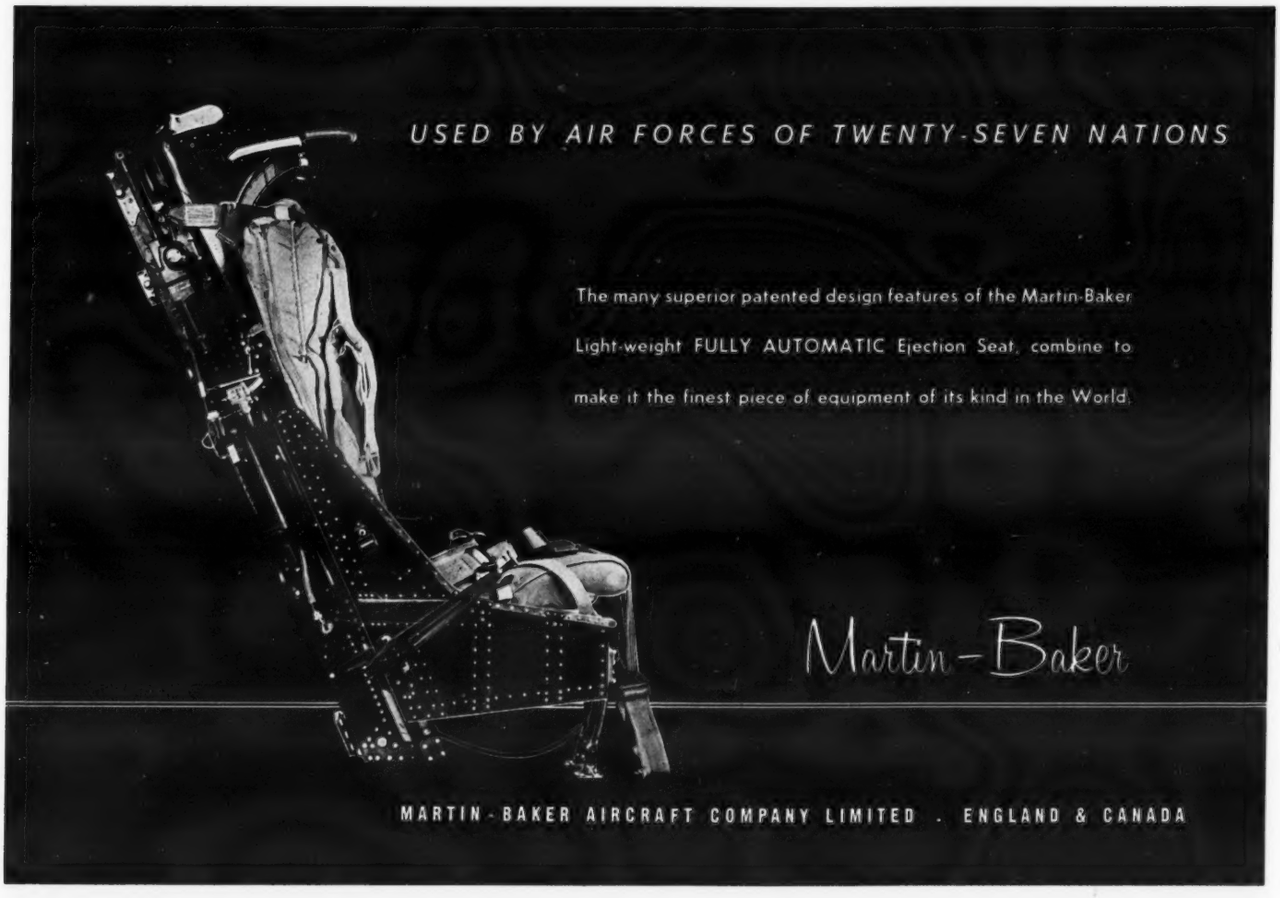
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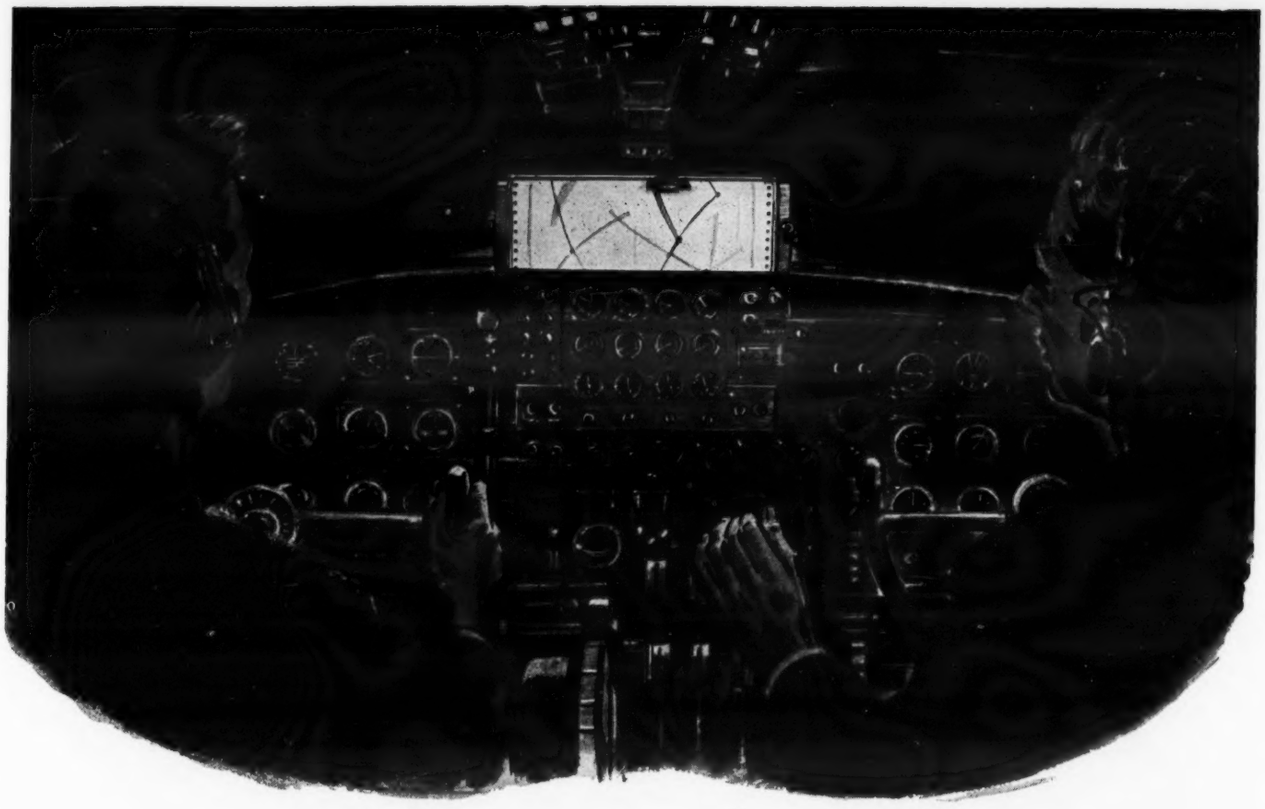

Future under Control

The introduction of high-speed, high-altitude jet aircraft will add to the air traffic control problems being encountered today.

The stringent operating characteristics of these aircraft emphasise the need for precise navigation so that climbs and descents through altitudes occupied by other aircraft can be carried out safely with minimum delay. The difficulty of providing vertical separation at high altitudes will also necessitate the lateral separation of these aircraft en route.

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World's leading airlines will fly this Boeing jet

Pictured above is the Boeing 707 jet transport as it will appear when deliveries begin late in 1958. Already 11 leading world airlines have purchased 134 Boeing jets.

The prototype model on which the 707 is based has, to date, completed more than two years of intensive flight testing. In addition, Boeing military jet transports developed from the same prototype will have built up thousands of hours of flight by 1958. The 707 will thus be the most thoroughly proven aircraft ever to enter commercial service. And it will incorporate many design refinements that can be achieved only by building and test-flying a prototype model.

The 707, cruising in the 575 mile-an-hour range, will permit such passenger-pleasing schedules as 6½ hours or less, New York to major European cities; 12 ¾ hours, San Francisco to Tokyo; and 16 hours flying time, Australia to the U.S.

Boeing's high-performance 707 will be an unusually versatile air liner. In a matter of hours its cabin can be arranged in any combination of first-class and tourist accommodations. The 707 Stratoliner will carry from 109 to 125 passengers. The 707 Intercontinental will handle up to 170 passengers.

These are the airlines that have ordered fleets of Boeing 707s: Air France, Air India, American, B.O.A.C., Braniff, Continental, Lufthansa, Pan American, Qantas, Sabena, and TWA. Behind the sleek, luxurious 707s is Boeing's record experience gained by building more than 1400 large, multi-engine jet aircraft—a background of experience unequalled by any other company.

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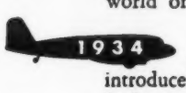
KLM inaugurates the world's oldest air service still maintained by the same company: Amsterdam-London.

KLM opens the first air traffic booking office in the world.

KLM is the first to make use of air-cooled engines and all-metal propellers, also since 1920 the first to introduce to the world the Fokker passenger planes which later on became the most widely used commercial aircraft in the world.

1927 KLM makes the world's first intercontinental charter flight: Amsterdam-Jakarta and -Khartoum.

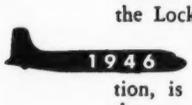
KLM opens the longest air route in the world of that time: Amsterdam-Jakarta.



KLM, as first airline outside the U.S., introduces the all-metal DC-2, wins the London-Melbourne Air Race handicap section.

1936 KLM is the first European company to purchase the world's most widely sold commercial aircraft: the DC-3.

1943 KLM, as first non-U.S. carrier, orders the Lockheed Constellation.



KLM, despite its war-shattered organization, is the first European airline company after the war to open a regular Trans-atlantic service to New York.

1948 KLM is the first European company to put the Convair Liners into service.

1950 KLM is the first European airline to be specially authorized by the U.S. Government to overhaul aircraft of U.S. airlines.

KLM is the world's first airline to operate the turbo compounded Lockheed Super Constellations.

KLM
ROYAL DUTCH AIRLINES

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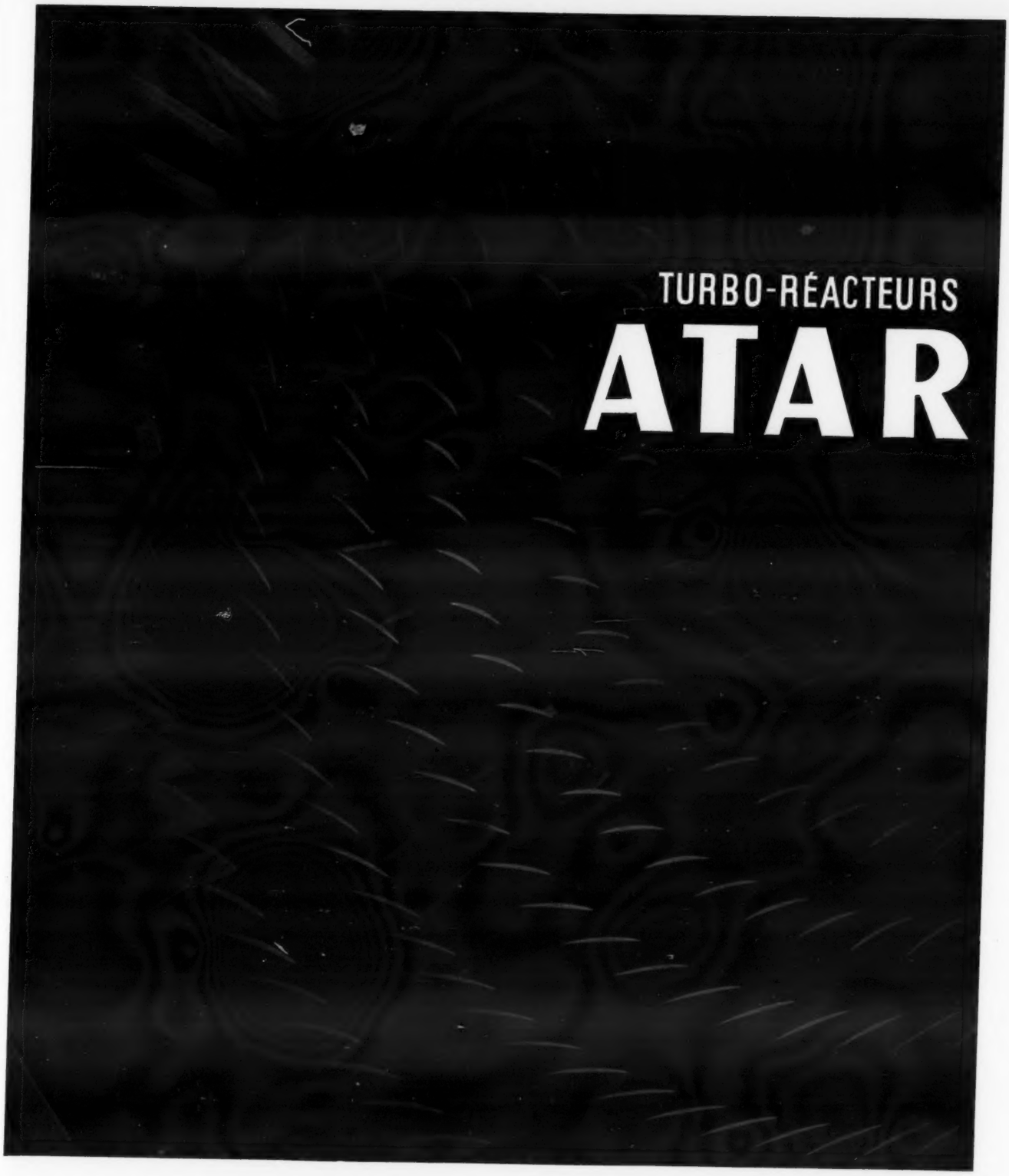
The General Secretariat of the Milan Fair, the Honorary Delegations of the Fair abroad and the Italian diplomatic and consular Representatives will be pleased to provide you with illustrative material, advice and assistance.

14th - 27th April 1957



SNECMA

150, Boulevard HAUSSMANN - PARIS-8e

HAVING A FLUTTER

This is an electronic analogue computer, designed and built by ENGLISH ELECTRIC for work at their Aircraft Division's Research establishment at Warton on problems of aircraft flutter and stability. A mathematician with a desk calculator would find it fairly easy to solve problems of flutter in two degrees of freedom, very difficult to solve problems in three degrees of freedom, and impossible to go further. This machine solves, in a few minutes, problems of flutter in six degrees of freedom. This does not mean that the mathematician becomes redundant. To produce the figures for a family of problems for the computer to work on may easily take him a fortnight. The computer then does in an hour or so what would take the mathematician 6 months to do—supposing he could do it at all.

On problems of stability the computer can do a theoretical analysis, which it can then translate into practical terms with the aid of a mock-up cockpit, complete with flying controls, simulated instruments and a cathode-ray artificial horizon. In this way a pilot can study the effects of different control and stability characteristics without ever leaving the ground—and can get a fair approximation of the feel of a projected aeroplane before it has been built.

Thus, with ever more elaborate equipment, are ENGLISH ELECTRIC designing today the aeroplanes of tomorrow. For when aircraft are required to fly at stratospheric heights and supersonic speeds, hopes and hunches must give way to science and certainty.

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INTERAVIA

Deadline Notes

No. 1, 1957

THE INTERNATIONAL AIR TRANSPORT ASSOCIATION Technical Committee has appointed a new Turbine Operations Panel to coordinate the joint efforts of the world's airlines to develop the most efficient flight procedures and requirements for the new generation of jet and turboprop aircraft. J. T. Dyment, Trans Canada Airlines, is Chairman, and other members are J. Boom, K.L.M.; Scott Flower, Pan American World Airways; Paul Frederickson, Trans World Airlines; E. L. Killip, British European Airways; Michel Phillipart, Air France; and A. C. Campbell Orde, British Overseas Airways Corporation. The Turbine Operations Panel will hold its first meeting in January. Results of its work will be circulated to airlines to assist their own planning and will also be submitted to the Jet Operations Panel of the International Civil Aviation Organization.

AIR TRANSPORT TALKS between Switzerland and the three Scandinavian countries were held in Berne in mid-December. According to a statement by the Federal Ministry of Posts and Railways, the main topic of the discussions was Switzerland's request that the present basis of civil aviation relations between Switzerland on the one hand and Denmark, Norway and Sweden on the other should be reviewed. The talks will be resumed on January 8th, 1957.

EUROPEAN CIVIL AVIATION CONFERENCE: Nicolas Detierre, Secretary to Willem Deswarte, Managing Director of Sabena, has been appointed Secretary General.

LINEE AEREE ITALIANE AND ALITALIA'S operating licences expire in March 1957, and Rome aviation circles expect that they will not be renewed in their present form. There is talk of coordination of Italian air transport, leading possibly to a unification of the two airlines. The Government apparently wishes Italy - like most other European countries - to be represented on international routes by a single airline. It has not yet been decided whether this object shall be achieved by creating an operating consortium or by merging L.A.I. and Alitalia.

GENERAL ALDO URBANI has been appointed new President of Linee Aeree Italiane, in succession to Prince Marcantonio Pacelli, who resigned in mid-December. As Chief of the Air Staff, General Urbani played a leading role in the reorganization of the Italian Air Force. He was replaced by General Ferdinando Raffaelli on reaching retiring age in the autumn of 1954.

SWISSAIR'S BOARD OF DIRECTORS has elected Dipl.-Ing. A. Baltensweiler, head of the Planning Department, to be a member of the Management Committee.

THE BRISTOL BRITANNIA is to be put into operation on passenger services between London and Johannesburg on February 1st, 1957. Services to Australia are also to be operated by Britannias from March onwards, and those to Hong Kong, Japan, Aden, Ceylon and Singapore from the middle of 1957 onwards.

EL MOMENTO ACTUAL DEL TRAFICO AEREO is the title of a survey of civil aviation today by César Gomez Lucia, General Manager of Iberia, Lineas Aéreas Espanolas. Written in readily understandable terms, it discusses aircraft and engines, air navigation questions and the development of air transport since 1943. A special chapter is devoted to air transport "on the threshold of the jet age".

NEW PRESIDENT OF TRANS WORLD AIRLINES is Carter L. Burgess, a former Assistant Secretary of Defense (Manpower and Personnel), who takes over the post left vacant since the death of Ralph S. Damon last January. In the intervening period Board Chairman Warren Lee Pierson has served as Acting President.

NORTHEAST AIRLINES has ordered five Bristol Britannias of the 300 series (305 version) for delivery beginning in October 1957. Total cost of order more than $17,000,000. The five transports were originally destined for B.O.A.C. To enable Bristol to meet the U.S. company's delivery requirements, the Corporation agreed to release five of the aircraft it had on order and to take five Britannias of the slightly later Mark 310 instead. The order brings the number of Britannias ordered up to 60: B.O.A.C. 33, Canadian Pacific Airlines 5, El Al Israel Airlines 3, Northeast Airlines 5, Royal Air Force 10, Ministry of Supply 4.

JAPAN AIR LINES has obtained two loans totalling $24,200,000 from the Export-Import Bank of Washington to help finance the purchase of eight passenger aircraft from Douglas Aircraft Co. The airline has four DC-8s and four DC-7Cs on order. The Bank's Board of Directors has announced one credit of $16,500,000 to be used towards payment for the DC-8s, together with spare parts and maintenance equipment. The overall cost of the jets is $29,000,000. The second loan amounts to $7,700,000 and will cover part of the $13,500,000 cost of the four DC-7Cs.

* From INTERAVIA's world-wide news service, including INTERAVIA AIR LETTER, the daily international aviation news digest. — No part may be reproduced without written permission.

THE SHORT SC-1 VTOL AIRCRAFT, which is powered by five Rolls-Royce RB.108 jets, has begun taxi tests at Short Brothers & Harland's Belfast airfield. The SC-1, formerly known as the PD-11, is the first British type designed for vertical take-off and landing combined with cruising in normal attitude. Under the test programme the taxi tests will be followed first by flight tests in normal attitude (take-off and landing as for conventional aircraft), later by hovering tests and finally vertical take-offs with transition to normal attitude and vertical landings. A special rig will be used for the hovering tests.

ROYAL NETHERLANDS AIRCRAFT FACTORIES FOKKER has received an order for two F.27 Friendship transports from the Iranian Oil Company, which has also taken an option on two more.

DEATH OF RENE COUZINET: From Paris comes news of the death of French aircraft designer René Couzinet, in whose "Arc-en-Ciel" Jean Mermoz became the first pilot to cross the South Atlantic both ways. The "Arc-en-Ciel" had an undercarriage with spats and, like its successors, a fuselage in one piece with the fin. Couzinet was also designer of a four-engine bomber, a wooden fighter and a twin-engine mailplane, which, however, never went into production. His last prototype appears to have been a rotary-wing aircraft.

THE SWISS AIR FORCE COMMAND CHANGES: Brigadier Colonel (equivalent to Brigadier General) Hermann Bachofner, Commander of the Swiss Air Force and head of the Flying Training Command, has resigned for reasons of health. He was succeeded on January 1st, 1957, by Colonel Hugo Troller, 54, of Dübendorf, who was at the same time promoted to Brigadier Colonel. An instructor with the flying units since 1930, Brigadier Colonel Troller was appointed Chief of Staff of the Flying and Anti-Aircraft Units on January 1st, 1956. For the past three years he has also been lecturer on aviation at the Federal Institute of Technology in Zurich.

THE SWISS AIR FORCE plans to equip two squadrons with twenty Mystère IVA fighters each, built by Générale Aéronautique Marcel Dassault. Total cost, including armament, ammunition, spare parts and maintenance equipment, will be approximately 100,000,000 Swiss francs.

THE NAVAL RESEARCH LABORATORY OF THE U.S. NAVY in cooperation with the Atomic Energy Commission, the Weather Bureau, and the Meteorological Services of Ecuador, Peru and Chile will undertake an expanded programme for the study of the distribution of natural and man-made radioactivity in the air. A network of 10 to 12 monitoring stations is planned for the 80th meridian West, extending from Greenland to Antartica. Seven of these stations are already in operation. The research will be conducted as part of the International Geophysical Year programme.

THE FRENCH AIR ESTIMATES FOR 1957, as prepared by the Air Ministry, amount to 286,000,000,000 francs, an increase of 1,000,000,000 francs over the Air Force budget for 1956. Economies introduced in the course of the year have cut down actual expenditure to 267,000,000,000 francs. The overall military budget - and this does not include military expenditure in North Africa and the Middle East - totals approximately 1,000,000,000,000 francs, a quarter of the national budget.

NEW CHIEF OF THE AUSTRALIAN AIR STAFF: Air Vice Marshal F. R. W. Scherger, Air Member for Personnel on the Air Board, has been appointed to succeed Air Marshal Sir John McCauley as Chief of the Australian Air Staff next March when Sir John retires.

*

WORKSHOP BRIEFS. . .

The first jigs for the Douglas DC-8 jet commercial transport have been set up in the new assembly shops constructed for production of this aircraft at Long Beach. * An increase in the zero-fuel weight and the max. landing weight is announced for the Fokker F.27 Friendships: zero-fuel weight to 32,210 lbs., max. permissible landing weight to 34,000 lbs. Max. take-off weight is also to be raised by about 1,000 lbs. The F.27 is in future to be fitted with the more powerful Rolls-Royce Dart RDa.7 engine of 1,700 s.h.p. + 500 lbs. residual thrust, with corresponding improvement in performance. * The Italian light-weight fighter, the Aerfer Sagittario 2, has reached a speed corresponding to Mach 1.1. in a shallow dive. * The Bristol Orion turboprop engine has completed 1,000 hours of operational tests since its first bench run on December 10th, 1955; more than 50 of these hours have been in the Britannia prototype (G-ALBO). - Six Orion prototypes have so far been built (four for bench tests, two for flight tests); a seventh engine is in construction. * The North American FJ-4B Fury carrier-based fighter has made its first flight, with Test Pilot George Hoskins at the controls. * A two-seat version, the F-104B, of the Lockheed Starfighter is in production, in addition to the single-seat F-104A supersonic fighter version. An RF-104A photographic version is also under development. * The new Northrop supersonic trainer, hitherto known as the TZ, has now been given the designation T-38. The U.S. Air Force plans to purchase about 400 of these trainers. * An undisclosed American aircraft manufacturer has offered several million dollars for patent rights to the jet flap developed in Britain. - The National Advisory Committee on Aeronautics recently issued a report on the jet flap which showed that take-off and landing could have been cut by about half if the jet flap had been applied to the DC-8 and the Boeing 707. * Hughes 269 is the type designation of a new light-weight helicopter for two persons, which is to be built for both civil and military uses.

* * *

Flight at Supersonic Speed

Revolution or Evolution?

If the air transport man is asked what was the most decisive event of 1956, he will point to the orders for some 300 Boeing, Douglas and Convair jet transports which will cut flying times in half by 1959.

If the air staff officer is asked the same question, he will hesitate before answering. Mentally he will review the latest developments in weapons systems, radar engineering and power plants. Few officers will probably decide to give first place to supersonic flight as it is taking shape on the threshold of 1957. To remove all doubt, *Interavia's* Editors have done just this.

The days when a "supersonic bang" caused a sensation are past. Two years ago, during the 21st Paris Air Show, the French capital's newspapers printed lengthy reports on the fact that French and other aircraft had produced bangs over the city centre, even breaking a few windows. At that time it was still an accomplishment to crash through the sound barrier in a shallow dive.

Since then progress has been so great that fighters and bombers whose level speed is not above Mach 1.5, or at least 930 m.p.h., will belong on the scrap heap in a few years' time. What supersonic aircraft are already under construction, how these designs were arrived at, what difficulties had to be overcome or still remain to be overcome, how it is planned to use the new equipment and what it is hoped to achieve with it, is discussed in the following articles. As readers will realize, the military are not yet agreed on whether the advance into true supersonic flight is an evolution or a revolution.

The urge towards supersonic flight probably went hand in hand with the urge towards flight at higher and higher altitudes—for meteorological and range reasons and above all out of considerations of military safety. As the new jet engines give their best performance only at altitude, supersonic flight came almost as a by-product. Originally aircraft designers thought that the thrust obtained from the turbojet plus afterburner would not suffice and sought an improvement by combining a turbojet with a rocket motor. It was left to the American engine industry to convince the doubters: with the Pratt & Whitney J-75 and the General Electric J-79—plus afterburner—today's American military aircraft have no need of rocket motors.

In order to combat bombers approaching at high altitudes, interceptors must reach these altitudes as rapidly as possible. Thus they must even be capable of climbing at supersonic speed. Similarly the most obvious way to protect the bomber was to give it the same speed as the fighter. The Convair *Hustler* bomber—at the moment the "sensation of sensations"—will doubtless lead the way here.

A year ago in these pages honour was paid to the "motorist", the engine manufacturer. This year the aircraft manufacturer has won the same right. What has been done for airframes and equipment, in the aerodynamic, thermal, structural strength, metallurgical and other fields, is an imposing achievement.

With this evolution or revolution—to leave the question open for the time being—the world becomes smaller even from the military point of view: it does, after all, make a vast difference whether an approach of 1,200 miles is covered in one hour or two, whether the ominous bomb with which it is hoped to deter an aggressor falls within one hour or two. Consideration has also had to be given to the men who are to fly such aircraft and use it as a weapon, so that the medical officer has also suddenly moved into the design office.

It is a truism to say that advances of this kind can be made only in the military field and cannot be applied to the civil side until many years later. The reasons remain unchanged: only the military have the funds to revolutionize technical development—to put it clearly for once—and only the soldier can be asked to risk his life to test new technological advances. The following figures quoted from an address by Air Commodore F. R. Banks, Board member of The Bristol Aeroplane Co., to the Royal Aeronautical Society illustrate the cost involved in developing a supersonic aircraft—and by no means the latest one:

Type	Engineering man-hours	Development period	Cost per production aircraft
P-51 *Mustang* fighter	250,000	1.8 years (1940—42)	$26,841
F-86A *Sabre* fighter	1,700,000	4.3 years (1945—49)	$121,000
F-100A *Super Sabre*	4,800,000	4.6 years (1951—55)	$486,000

How many hundred million dollars the U.S. Congress provided for North American and the Pentagon for these three designs, only the manufacturers know.

All this suggests that the airlines can calm their fears: the roughly $3,000,000,000 which are now being scraped together to introduce jet airliners with subsonic speeds will doubtless remain a relatively safe investment for some long time to come. The multi-jet *Hustler* bomber is still only at the beginning of its career, and there can at present be no question of a supersonic commercial transport. There is still a long way to go before even a small number of manufacturers can acquire sufficient experience and funds to tackle a supersonic transport. Passengers must still content themselves with cruising speeds of less than 600 m.p.h. For how much longer? On the threshold of 1957 we too can venture on a prediction: At least a good ten years.

EEH

Supersonics

Supersonic Strategy

By Brigadier General Dale O. Smith, U.S.A.F.,
Bethesda, Maryland

(The views expressed are those of the author and are not to be construed as reporting official or unofficial policies of the United States Air Force or any other government agency. General Smith is the author of a recent book, *U.S. Military Doctrine*, published by Duell, Sloan & Pearce.)

"In a period of inattention, by chance or design, one nation might be destroyed by the other before the victim could retaliate." These North American F-100 *Super Sabres* of the U. S. Air Force 479th Day Fighter Wing above George AFB, California, show that America has no intention of submitting to a second Pearl Harbor.

Human conflict is inevitable as long as people continue to have conflicting aspirations, and marriage does not magically eliminate all differences. Revolutions and rebellions seem to be as prevalent, for example, as international wars. Fortunately, however, rebellions seldom take on the proportions of highly organized area warfare.

People will continue to fight, but the issues over which they fight will undoubtedly be somewhat different than those which offend and anger us today, just as today's inflammatory issues are different from those of a few centuries back, when questions of religious doctrine could cause a Thirty Years' War. Today's differences center around political ideologies, economics and nationalism; tomorrow's conflicts may generate from more subtle influences which bother us little today. Social and political philosophies often overlook the fact that people can never understand and accept each other unconditionally, even when in the same bed.

It is safe to assume, therefore, that war will still be possible in the supersonic age of rapid and widespread travel: What form, then, might warfare take? What kinds of strategies might evolve in such an age?

We know, of course, that this future age of supersonics will be accompanied by almost unlimited munitions. Efforts will continue to control and curb the use of catastrophic weapons, but no legalistic efforts will ever erase the knowledge so far gained from the minds and recordings of mankind. These massive weapons, therefore, must always be considered in our prophecies. They have become a real phenomenon of our lives which we must learn to deal with, for we can never wish them into oblivion.

Some predict that a world of supersonic air vehicles able to carry nuclear warheads through intercontinental ranges, will obviate the need for advanced bases, and thus permit the formation of formidable national fortresses. The "Fortress America" concept springs from this prediction but the concept is undoubtedly influenced by the wish for the good old days. America's 19th century isolation policy presents a nostalgic picture of security and prosperity with few international problems or responsibilities. It would be good to turn back the clock, but it is impossible.

From a cultural point of view, supersonic commerce will steadily erode the concept of isolation. Self-sufficiency is possible and will continue to be so in certain large countries. But people are not content with self-sufficiency even if it were to bring peace. People want to have the same good life as their neighbours, and they will risk danger to get it. Rapid and low-cost trade and travel will be a necessary prerequisite, as it is now, to prosperity. Isolation cannot survive as a practical political philosophy; certainly not in the supersonic age.

Nor will supersonics contribute to military isolation. As Einstein demonstrated, speed is relative, and when supersonics develop concurrently in two opposing countries, the increased tempo of warfare does not change the basic tactical and strategic relationships.

Advanced bases, for example have often been justified in terms of limited aircraft ranges. Intercontinental ranges could not heretofore be achieved by higher performance aircraft. But a more fundamental reason for advanced bases—a reason common to all warfare even before the days of cavalry—is that the enemy can be struck before he can strike at you. Supersonics do not change this equation of war.

No matter how fast war vehicles travel, distances on the surface of the earth present a constant factor, as does the phenomenon of time. If two belligerents oppose each other, each with intercontinental ballistic missiles of Mach 10 speeds, or even of Mach 20 speeds, that side which has launching sites nearer to the other's targets will always have a distinct advantage.

Let us say that countries A and B were 5,000 miles apart and each were armed with Mach 10 I.C.B.M.'s. The time of flight between them would be roughly one hour. But suppose country A had launching sites half way to country B, while country B had no such advanced bases. Country A could strike targets in country B just one half hour after a decision to do so. Country B could not reach targets in country A within one hour. (The same equation is valid when considering manned bombers, which will always hold certain unique military assets.)

One might say, what difference will 30 minutes advantage make? But this is a conclusion built on despair. Certainly there can be other conclusions, equally logical, and supported by considerably more evidence.

Let us go back to our hypothetical situation where country A has achieved a geographical advantage over country B by having advanced launching sites. Each is poised, you might say, with loaded guns at each other's temple, except that one has a hair trigger of thirty minutes,

The dispute between the three U. S. services on the possession of guided missiles was recently settled by Defense Secretary Charles E. Wilson, who ruled that the U. S. Air Force is alone to operate long-range weapons. —A Northrop SM-62 *Snark* strategic missile under test at Patrick AFB, Florida.

while the other has a much slower trigger of one hour. Who, then, has the military advantage? If country A had no intention of pulling the trigger except in self-defense, would not A be put in a position of deterring country B from taking a gamble? Assuming all other factors equal, country B would be faced with a fixed disadvantage in time and space.

It has often been predicted that a mutual deterrent would be established when two opposing nations achieved an intercontinental nuclear capability. That if one took the initiative, the other could launch its retaliation regardless, and each would be destroyed. This concept is a gross oversimplification of military strategy, for equality in weapons and delivery systems do not reflect equality in other factors of war. With fire power a constant, other factors of war then take on decisive features. Factors such as surprise, intelligence, and air defense are rapidly growing in significance.

Let us examine surprise for a moment. If two enemies are holding loaded guns at each other's temple, each must be fully attentive to the danger if a mutual deterrent is to maintain. One or the other will, perhaps, attend to something else momentarily, such as the distracting noise of an opening door. And then he will draw his last breath. Or, should one of the duellists grow tired of the strain and wished to get it over with, he might contribute to the other's diversion of attention with some ruse, such as the one used in motion pictures, "Look, someone is behind you!" The Sunday morning attack at Pearl Harbor and the Christmas season Ardennes offensive are typical.

Nations, too, grow inattentive. Fear cannot force us as individuals or as nations to be fully attentive to danger at all times. Therefore, the concept of mutual deterrence becomes meaningless. In a period of inattention, by chance or design, one nation might be destroyed by the other before the victim could retaliate. The mutual deterrent concept through equality of weapons strikes too precarious a balance.

On the other hand, history indicates that the surest deterrent to war is for nation A to have a distinct military advantage over nation B, and that both nation A and nation B know this advantage to be real. In the past, superior nation A has generally used this advantage in conquest to amass land, wealth and power. But today, if nation A has no such ambition, if nation A truly desires peace, a real deterrent can be achieved.

The Convair F-102A supersonic all-weather fighter is in production for the U.S.A.F. at Convair's San Diego plant, California.

A flight of North American F-100 *Super Sabres* over Nellis AFB, Nevada.

Designed for tactical missions, the new TM-61B version of the Martin *Matador* is to have an entirely new type of guidance system.

The key to such a deterrent, however, is continued military superiority and alertness to the danger of the supersonic nuclear age. Should country A become inattentive and allow country B to excel in delivery systems, the geographical advantage of advanced bases may be nullified. For example, if B's weapons could be launched at Mach 20, while A held on to her older Mach 10 weapons, each could strike the other simultaneously. The deterrent factor of advance bases once held by A would have been cancelled by B's increased weapon speed.

Country A, therefore, can only expect to survive if it continues to progress technologically at a rate greater than country B. Never can its research and development guard be dropped. Never can it lag in educating for science, engineering and military arts. Never can it relax into complacency because of any military advantage it may enjoy, for such advantage can only be transitory in a dynamic, changing world. Of most importance, it must be mobilized at all times with decisive forces, alert for instant action.

Supersonic speeds, of course, enhance the possibilities of tactical surprise in warfare. There seems no likelihood of a single nation being safe unless it is allied with many others to provide enough space on the globe for adequate warning of air attack.

Perhaps no activity of the supersonic age will demand such close international cooperation and trust as the air defense system. No single endeavour will encompass such vast reaches of territory and demand such lightning swift responses from defending forces.

The United States and Canada have pushed out their warning system step by step in order to have more time to react. The DEW line, coupled with Texas Tower radar stations in the ocean, and air and surface picket ships represent the latest extensions. But with increasing bomber ranges and speeds, end runs and supersonic penetrations threaten the adequacy of even this elaborate system. Certainly in time to come the whole free world will, of necessity, have to be tied in to a single air warning and defense net of a highly integrated and coordinated nature. Only then can tactical surprise and its horrible consequences be prevented.

The demands of an adequate air defense system in the supersonic age will argue strongly against neutralism. The free nations must band together or, in the words of an early American patriot, hang separately.

Some people feel that their country might avoid atomic bombardment by remaining neutral. If a country contained strategic targets, neutralism would hardly deter a desperate aggressor, as witness Belgium in 1914, and Norway in 1940. However, in the supersonic age, major warfare will most likely burst over the centers of power: the United States and Asia. In all probability, the historical battle grounds of Europe will remain historical, for the more strategic targets in an all-out air war will be found at the more immediate sources of power.

Supersonics

Convair F-102A all-weather fighters.

The Impact of High Speeds on Conventional Strategy

By "MILES"

The first Lockheed F-104 interceptors were scheduled to be assigned to squadrons of the U.S.A.F.'s Continental Air Defense Command at the very beginning of this year, and the U.S. Navy announces that at least two of its squadrons at Moffett Field and Atlantic City, will be equipped during 1956 with Chance Vought *Crusaders,* whose level speed is officially reported to exceed 1,000 m. p. h. The North American F-107 is said to have flown at Mach 2 in level flight. With these aircraft and such others as the Convair F-102A, the Grumman *Tiger*, the North American F-100C, the Republic F-105, the McDonnell F-101A and the Convair B-58 *Hustler,* the United States combat units have a range of equipment whose operational speeds run from at least 800 to 1,200 m. p. h. From the aeronautical point of view, therefore, the years 1956 and 1957 are marked by the levelling of the sonic hump and the arrival of military aircraft face-to-face with the new problems of supersonic flight: lift and stability, friction heating, take-off and landing problems on runways of acceptable length, armament, protection for the crew, etc.

Ten years ago designers were still unable to offer high subsonic speeds and range in the same aircraft. The F-86E exceeded 620 m. p. h. but only over relatively short distances, while the B-36 bomber had "inter-continental" range but a cruising speed of only 280 m. p. h. The Boeing B-47 was already faster, with a Mach number exceeding 0.85, but had to be refuelled in flight in order to carry out lengthy missions. Similarly, today, the Convair B-58 *Hustler* should fall within the 800 to 1,200 m. p. h. speed range chosen above as criterion, but will not have the endurance of a heavier, but slower, aircraft such as the Boeing B-52.

In 1957 the U. S. Navy plans to equip at least two squadrons with the Chance Vought F8U *Crusader*, a day fighter whose level speed is officially stated to exceed 1,000 m.p.h.

All these designs, whether yesterday's subsonic or today's supersonic types, are the result of a strict compromise between irreconcilable requirements. In practice, the compromise is sometimes weighted towards speed at the expense of range, at other times towards range at the expense of speed. The world is too big for the engineers yet to have succeeded in combining the maximum speeds operationally obtainable with the kind of range required by political and geographical considerations. But as aerodynamics progresses and fuels—whether simple or complex—with greater calorific power are discovered, it becomes possible to arrive at a better compromise by improving both speed and range. Even in its present form the B-58 *Hustler* illustrates this advance.

The military repercussions of this rapid increase in speeds (and, more generally speaking, the fact that the range/speed compromise can be obtained at increasingly high performance levels) are numerous and of the utmost importance.

The Pentagon's plans for the Republic F-105 and the Convair B-58 have not been revealed. Both would reportedly carry one or more nuclear weapons, on different missions, at speeds in the neighbourhood of 1,000 to 1,100 m. p. h. One of the Lockheed F-104 versions is also said to have the same offensive capability, at any rate as regards the carriage of an atomic bomb if not as regards the distance over which this bomb could be launched. Even in the days when the Hiroshima bomb had a real destructive power equivalent to at least 2,000 tons of T.N.T.[1], one single bomber could replace 400 or 500 B-29s. Today, the reduced size and weight of atomic bombs enables even small aircraft to be given a tremendous destructive potential. It is already four years since the U.S. Air Force announced that the Republic F-84E and F-84F could carry atomic weapons. The entry into service of the Century

[1] Its real power; theoretically it was equivalent to 20 kilotons of T.N.T.

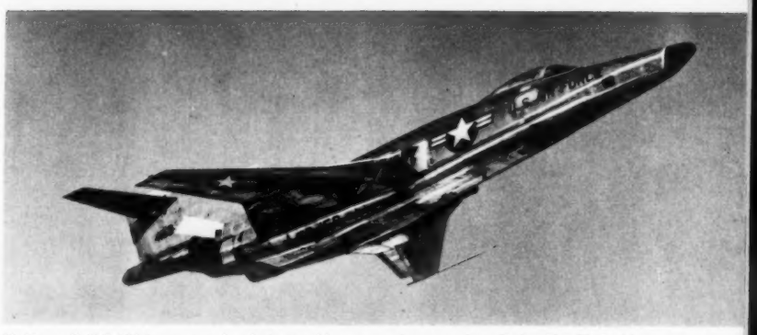
"fighters" marks a new stage, the carriage of an imposing "quantity" of destruction over short distances at speeds ranging from 800 to 1,200 m. p. h. Better still, the United States possesses, in the *Hustler,* a substantially supersonic aircraft capable of navigating and of attacking its targets in any kind of weather. Its speed can be compared favourably with that of most of the interceptors now in service or in the assembly shops. Its sole limitation is its range, a limitation that either cuts it back to a relatively short-distance strategy or necessitates in-flight refuelling, with the attendant complications involved in choosing a suitable meeting point for bomber and tanker in relation to the "front line".

As regards the relative speeds of aircraft carrying an air-to-surface projectile (bomb or guided missile) and the interception equipment that would be used by the defence, the latter's speed margin over the former becomes insignificant if the "bomber" takes off from a base relatively near its targets. In other words, the speed margin that has hitherto existed between offensive and defensive equipment, both piloted, retains its value from the operational point of view only if the distance to be covered by the bomber exceeds a certain limit, i. e., when such a heavy load of fuel has to be carried that the aircraft's gross weight would make supersonic speeds impossible.

Under these conditions the following hypothesis becomes perfectly plausible. Let us assume that two years from now the aero-nuclear Powers possess an aircraft carrying atomic weapons and capable of cruising at 1,000 m. p. h. over a distance of 1,000 miles from its departure base to its target. By the same period, i. e., from 1958 to 1962, these same Powers would be unlikely to have interception equipment in service with a speed sufficiently superior to ensure effective intervention, even if endurance is cut down to the bare minimum required for guidance and the actual interception manoeuvre. It must also be assumed that the defensive weapons system then available, whose efficiency would depend on the amount of warning received, the rate of climb, the guidance system, the efficiency of air-to-air missiles launched at supersonic speeds against a supersonic target, would have only a very limited stopping power. It follows that over short distances, that is, for the protection of targets within a strip of territory 1,000 miles in depth whose furthest regions could be reached by the attacking aircraft in less than an hour, the defence will be up against a singularly difficult, if not impossible, task.

Defence not dead

In fact, however, the reality is far less categoric than the theory. The use of "collision course" air-to-air missiles would limit the distance which the attacker could cover with impunity. If the "bomber" attacks in "pursuit" and even if the fighter's speed margin over the bomb carrier is only 3 miles per minute, it can make good an initial gap of 30 miles between the two aircraft in 10 minutes, a flying time entirely compatible with the endurance of a very light, and hence fast, interceptor. A few months ago Lockheed hinted that a fighter-bomber version of the F-104, with a range of 1,550 miles, might be built. The extra fuel carried by this version would probably reduce its maximum speed, so that if the two versions were opposed to one another there would be a speed margin of a few miles per minute in favour of the aircraft operating with minimum range, as in the above hypothesis.



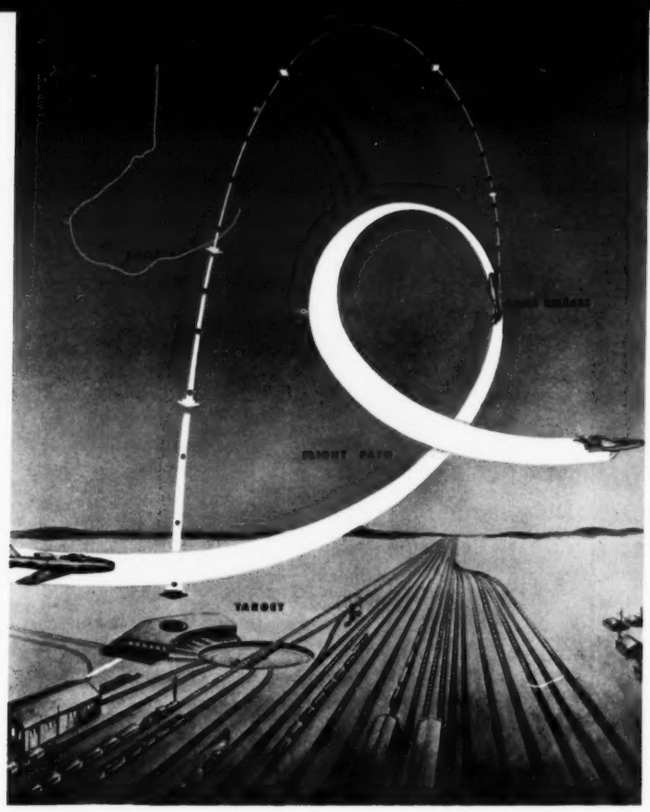
McDonnell RF-101A supersonic photographic reconnaissance aircraft for the U. S. Air Force.

This leads to the realization that the depth of front-line territory which would be indefensible does not depend solely on the warning time, or the efficiency of the communications services and guidance system, *but is closely connected with the minimum endurance which the interceptor must have in order to accomplish its mission.* This endurance determines the fuel load, which in turn fixes the aircraft weight and general aerodynamic configuration. It is now fifteen years since Professor Lippisch carried this reasoning to its extreme in the Me 163 *Komet,* obtaining a speed (around 600 m. p. h.) and a climb performance that were exceptional at the time. But endurance was reduced to a few minutes. Guidance from the ground in bad weather was impossible, and the Me 163B could defend no more than an area stretching some 40 to 50 miles around its base. Its missions, in themselves successful, were limited to attacking formations of bombers passing nearby. All in all, as regards both its performance and its limited operational capability, it was already closer to a surface-to-air missile than to a fighter. This configuration has not been copied elsewhere. Since then, greater attention has had to be given to range, in view of the increasing demand for all-weather operations and the fundamental change in attack tactics introduced by the atomic bomb, since a single aircraft now represents the same destructive potential as several hundred or even several thousand heavy bombers carrying T.N.T. bombs.

The increase in weight of the airborne equipment required for gunnery and navigation in all weathers, the improvement in range needed to ensure efficient control from the ground, the time taken to get into firing position—with allowance for a second attempt if the first fails—

A few months ago Lockheed mentioned a fighter-bomber version of the F-104, with a maximum range of 1,550 miles. The long-range version's extra fuel (carried in wing-tip tanks) would reduce maximum speed only slightly.

The price of increased speed is loss of range. As nobody is anxious to pay, all try to get out of it by in-flight refuelling. Three North American F-100 *Super Sabre* supersonic fighters taking up a "range loan" from a Boeing KB-50 tanker.



"Over-the-shoulder" bombing, the U.S.A.F.'s new method of attack by low-flying transonic and supersonic fighter-bombers. In this particular case the target is a locomotive shed in a marshalling yard.

and return to a base which the aircraft has left behind at a rate of 20 to 25 miles per minute, have all led at least to an intermediate solution, somewhere between yesterday's *Komet* and the heavy all-weather fighter such as has been developed during the past ten years.

If the take-off weight of such an aircraft is set at 7 to 8 tons—here the aircraft in mind is obviously the Lockheed F-104—the problem which arises is to know what would be the radius of action of an aircraft of this weight carrying a nuclear weapon of a weight equivalent to the fighter's armament and flying at a speed close to the latter's. It is this operational radius of action which determines the depth of the zone within which both offensive and defensive equipment would operate at equivalent speeds. It is also conceivable that, in certain circumstances in an atomic conflict, one-way missions might be envisaged. In that case, the depth of the area that would be difficult to defend by conventional means would be doubled.

Distortion of geography

If this "equal speed" zone were found to be of considerable depth, it would lead to a veritable distortion of military geography. We have already seen the globe shrink. The fact that speeds have been multiplied by at least three during the past twenty years has reduced distances over continents and oceans correspondingly. Today, the concept of a zone that is difficult to defend by conventional means adds a further complication. The methods, the means and the tactics still valid outside this zone are no longer applicable inside it.

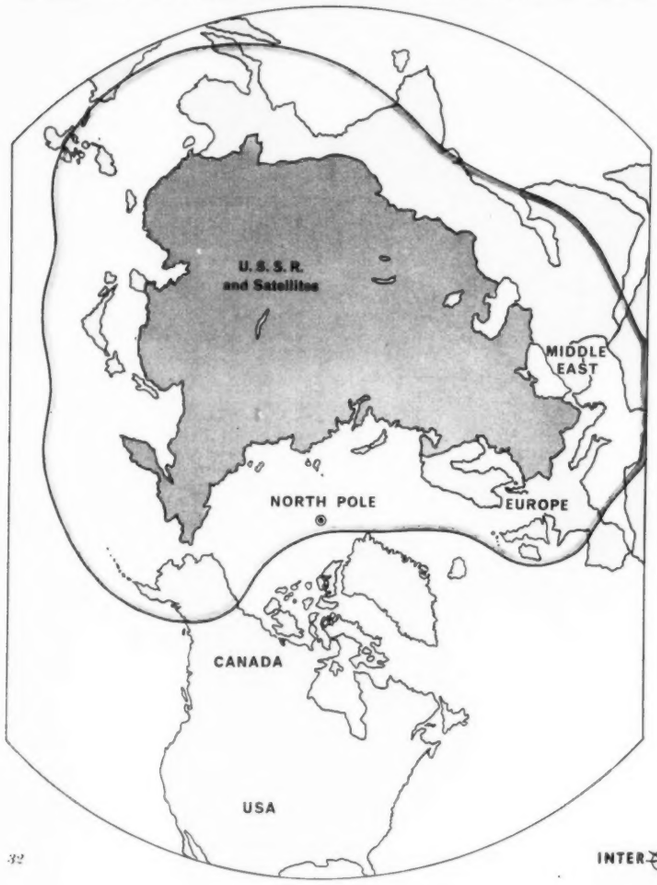
Zones in which attacker and defender would have equal speeds

If the theory advanced in this article is proved correct, namely that the speeds of manned fighters and bombers would balance each other up to a penetration depth of 1,000 miles, this would produce a zone which would be almost impossible to defend by conventional means.

The first map (left) shows the "zone of equal speeds" in the territory of the *Western Powers*. It covers Western Europe and the Mediterranean region—almost all of it—as well as Alaska. The "zone of equal speeds" in the *Eastern Powers'* territory is less extensive: part of the People's Republic of China, Kamchatka, the Kola peninsula and the major part of European Russia and the Caspian Sea.

A notable point is the relative safety of the North American Continent from supersonic bombers.

It should be stressed that the hypothesis applies only to *future* supersonic bombers. As the bombers in service today have speeds in the 500 to 650 m. p. h. range only, modern supersonic fighters (1,000 m. p. h.) have sufficient speed margin to defend a large portion of the "danger zone" successfully.



A Revolutionary Design

The Convair B-58 "Hustler" Multiple Weapons System

By Interavia Study Group

An aircraft built under an entirely new concept adopted by the U. S. Air Force has just reached the practical flying stage, after being seven years in the development process. This is the Convair B-58 *Hustler*, first concrete example of the "multiple weapons system" concept, which has already superseded the weapons system concept of but recent introduction.

The B-58 is designed to carry an atomic bomb at well above sonic speeds, act as a strategic reconnaissance aircraft, fire guided missiles, serve as a control station for electronic counter-measures or as an intruder fighter. Its speed, armament and electronic equipment could make it a very versatile machine, capable of winning the day in several domains of aerial combat, even against more specialized aircraft.

The *Hustler* came out of the Fort Worth assembly plant of General Dynamic Corp.'s Convair Division a few weeks ago and made its first flight on November 11th. The forthcoming tests will show whether, having invested several hundred million dollars in the design and development of this weapons system, the United States now really possesses a decisive instrument. For the task of destroying static targets, the *Hustler* may well be the last, or at any rate the last but one, aircraft to carry a human crew.

From the very first design studies, somewhere around 1950, it was decided that the B-58 should be capable of a variety of different missions. At that time the best interceptor fighters in service barely reached a rate of climb of 10,000 ft./min. From the start the Convair project was a great deal more ambitious as regards both rate of climb and, above all, level speed, and it was natural to aim at a "multiple weapons system". Needless to say, as the months and years went by, the U.S.A.F.'s requirements became more stringent, while engineering developments provided new ways of meeting these requirements. The *Hustler* project was thus a sort of continuous creation, constantly helped along by new discoveries and new technical achievements. As the prime contractor, Convair coordinated development in hundreds of subsidiary fields, from metallurgy to electronics via propulsion units, nuclear and conventional armament, guidance systems for missiles and physiological conditions for the crew at high altitudes and the high accelerations suffered at bisonic speeds. A thousand different research fields, from cybernetics for the operational development of the system of hypersonic aerodynamics, were mobilized in the service of Convair.

Interavia was among the first to stress the military significance of the B-47[1], pointing out that the six-jet Boeing bomber was the best possible compromise between high speeds and heavy striking power. Today, with the announcement of the B-58's characteristics and qualities, it is tempting to return to this subject and to expatiate on the capabilities and the limitations of the new weapons system with which the U. S. Air Force may later be equipped.

[1] *Bomber Parade* No. 3, 1952.

But first, what does the B-58 look like? Thanks to an indiscreet photographer, the *Hustler's* features became known to the aviation world almost as soon as it left the assembly shop. It is a delta-wing design, whose general dimensions are relatively small compared with those of its predecessor, the B-47: length approx. 95 ft., span roughly 55 ft., overall height to top of tail unit 30 ft. Both manufacturers and official circles are silent on the subject of weight, which can be estimated to be around sixty tons. The aircraft has been designed according to the area rule, with allowance for engines housed in underwing pods. The leading edge sweep of the delta wing appears to be about 60°; thanks to the wing's deep chord, it has been possible to obtain a very low thickness/chord ratio—around 4%. Angle of incidence in relation to the fuselage's longitudinal axis is high, doubtless in view of the aircraft's configuration in high altitude flight. Very long undercarriage legs, probably retracted forwards, each carry eight wheels in groups of four. These wheels are extremely small (overall diameter 22 ins.) and are equipped with special high pressure tyres. The nose unit has twin wheels, which are retracted rearwards into the fuselage. Three cockpits, one behind the other, house the pilot, the navigator/bombardier and the operator for the defence weapons system, in a similar arrangement to that of the B-47.

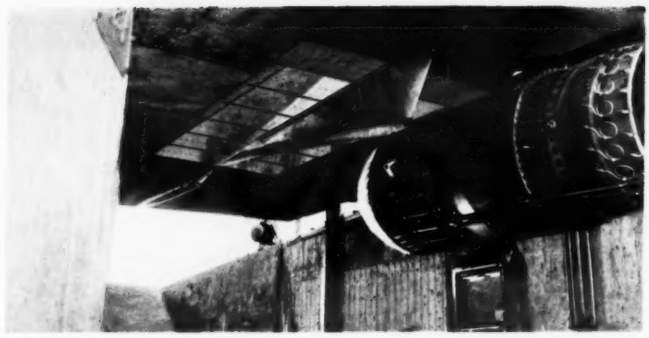
The first prototype of the Convair B-58 *Hustler* rolled out of the assembly shop at Fort Worth in mid-November.

The engines selected are General Electric J-79 jets, which have a static thrust, with afterburner, of some 15,000 to 18,000 lbs. in the present production version. The exact characteristics of this engine are still secret, but its performance is known to be sufficiently revolutionary to confer considerable advantages on those manufacturers able to make use of it.

The heat problem

The combination of delta wing and external power units set Convair's design engineers some stiff problems. The jets had to be placed

Three-view drawing of the B-58.



Test rig for measuring surface temperatures and vibrations in the *Hustler* wing, using a Pratt & Whitney J-57 jet.

sufficiently far in front of the wing's centre of pressure line to obtain a satisfactory balance, but at the same time measures had to be taken to reduce heating of the wing by engine exhaust gases. The latter danger had to be overcome in all flight phases, in climb, cruising at high altitude with high angle of attack and during taxying on the ground when the speed of the ambient air is very low. Such heating would have been all the more critical since the major part of the wing was to be built as an integral fuel tank. Because of the aircraft's reduced dimensions, the shape of the fuselage and the very high consumption even in cruising flight, fuselage tanks could not be used, so that all fuel has to be carried in the wing. The risk involved in presenting so vulnerable a target to surface-to-air or air-to-air defensive missiles is reduced by the type of mission on which the *Hustler* would be employed, its relatively small dimensions and its high speed.

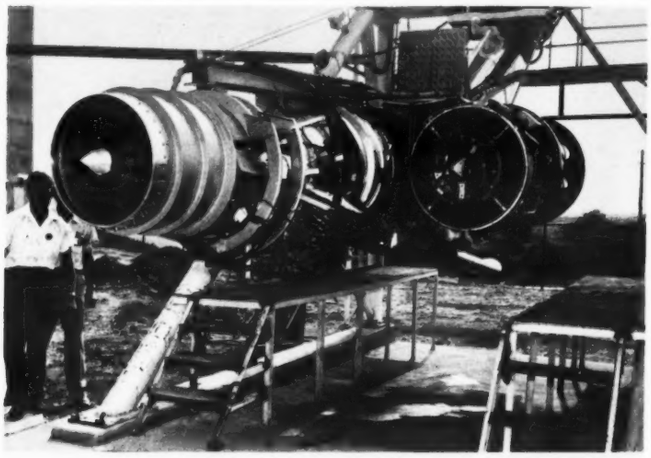
The optimum arrangement for the jets was arrived at after long and complicated calculations and protracted experiments with full-scale models. The original plan of fitting the engines two-by-two in double pods had to be abandoned, since tests had shown that it would lead to excessive heating of the wing, particularly during taxying and take-off. Further wind tunnel trials revealed that the drag of the four jets mounted separately remained within permissible limits, while the heating effect at the end of the jet pipes was greatly reduced.

The inboard power units are attached at about 40% of the half-span, on long pylons stretching well forward of the wing leading edge. The outboard engines are mounted directly beneath the wing at about 85% of the half-span, with the jet exhaust nozzles projecting beyond the wing trailing edge and thus reducing the heating problem. Calculations and wind tunnel tests also showed that this distribution of the power units over span and chord fits in better with the area rule principle. The combination of the wing and fuselage sections with those of the engine pods gave frontal areas which met the aerodynamic requirements of the area rule.

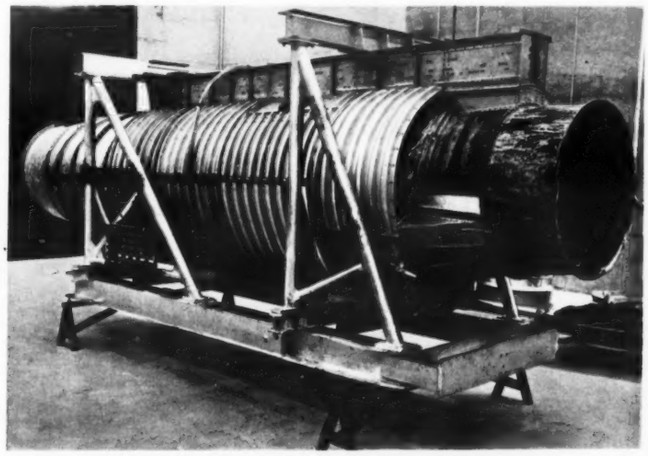
Nevertheless, this distribution of the engines, even on long pylons, was not sufficient in itself to overcome completely the wing heating problem, particularly during take-off and at altitude. The wing structure was designed to make allowance for this difficulty, and the angle between the inboard jet's longitudinal axis and the wing chord was modified. Also, the B-58 is the first production—or at any rate pre-production—aircraft in which sandwich plates of stainless steel are used as the main stressed units. Altogether 15% of the aircraft's surface, including of course parts of the wing underside, the engine nacelles and the pylons, is built up of steel honeycomb. Less temperature-stressed parts of the surface are made of sandwich structures with aluminium alloy plates and aluminium or fibreglass filling. Tests revealed that the sandwich construction avoids heat sinks and heat bulges (hence good surface quality) and gives very favourable strength/weight ratios.

Another phenomenon, this time a dynamic one, that needed investigation was the influence of vibration effects from the engine gas jets on the underside of the wing. Using a J-57 jet mounted beneath a portion of wing with the

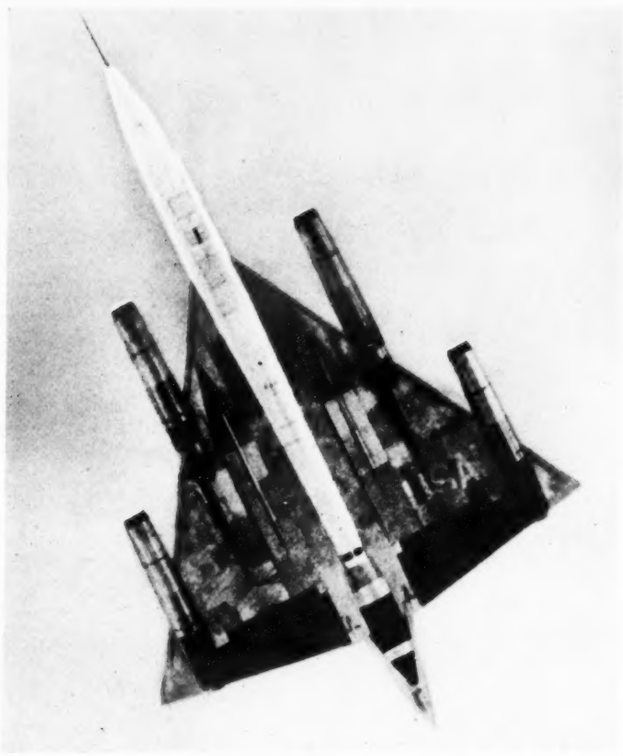
The twin engine pod originally planned. The pipe projecting sideways from the compressor housing of the port engine contains the pump to accelerate the secondary air.

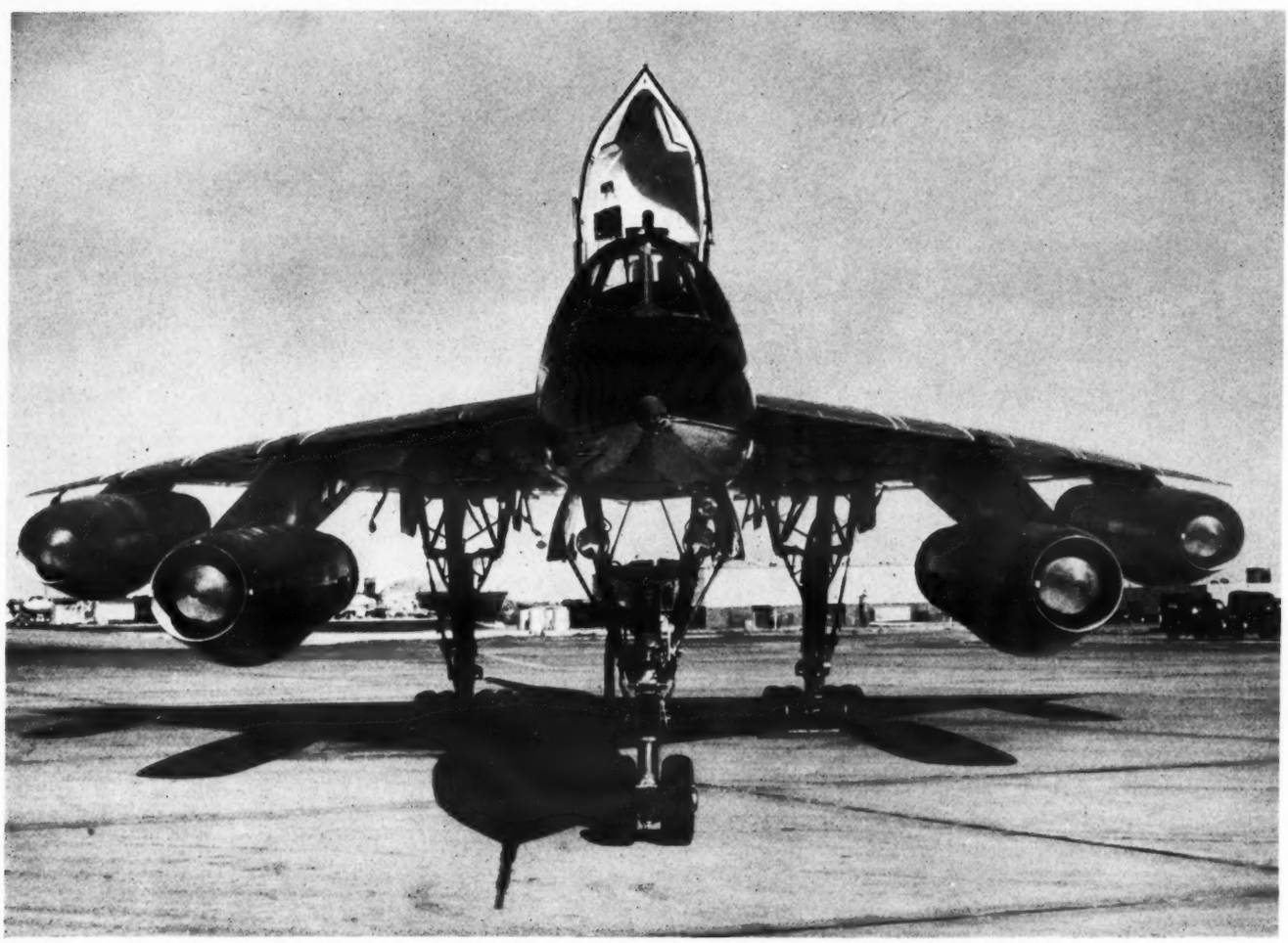


First version of the single engine pod (final solution) with ovoid section to accommodate the secondary air duct for cooling the accessories.



U.S. AIR FORCE





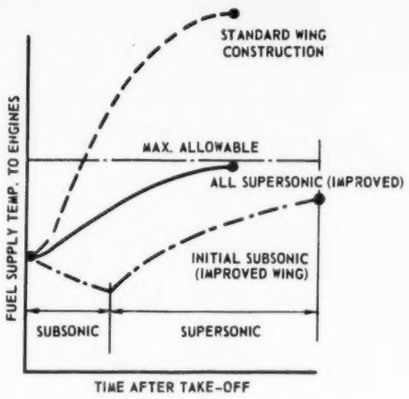
same elasticity qualities as that of the future *Hustler*, Convair engineers investigated all aspects of this phenomenon, including resonance effects, in all flight configurations. All that is known is that special measures were taken as a result of these tests.

The Hustler considered as a thermodynamic whole

So far, reference has been made only to the heating problems arising through the combination of a delta wing and large power units. As it was to be appreciably supersonic, the *Hustler* had to be designed to push back as far as possible what is incorrectly known as the "heat barrier". Allowance had to be made for the effects of friction heating on an extremely thin wing, with a large contact area and filled with fuel. Pressurization and sealing of the tanks, elasticity of the wing, evaporation of fuel, the cooling properties of the fuel and the effects of the progressive reduction in fuel volume were all possible sources of difficulties which had to be examined and solved for all flight conditions, that is to say as a function of speed in all layers of the atmosphere and hence of friction heating. Despite the use of insulation (the air imprisoned in the honeycomb serves as heat insulation), the temperature of the fuel remaining at the end of a mission and during supersonic flight could have been excessive. Tests revealed, however, that a brief period of flight at a lower speed would considerably cool the fuel and that it would be necessary, for certain missions, to accept an alternation of supersonic and subsonic flight.

To avoid unnecessary fuel heating on the ground as a result of the large area exposed to the sun's ray, Convair proposes the use of a special white finish for improved reflection of solar radiation, ventilated covers to protect the wing or a system of refrigeration.

A special study was made in order to determine the optimum characteristics and the optimum configuration of the fuel circuits so as to allow both for the maximum permissible temperature of the tanks on take-off and for the fuel temperature on injection into the combustion chambers. As the two limit temperatures are very different and the first is lower than the second, the thermodynamicist had a wide heat margin which he could use for general cooling of the circuits. Expanding this idea, Convair engineers decided to apply it not only to the fuel circuits but also to all the circulation systems (oil, hydraulic fluids, etc.), or in other words to treat the complete aircraft as a thermodynamic whole. In this way it was possible to calculate the different operating temperatures of the various items of equipment and to use the heat sink in order to arrive at a coherent thermal system.



Increase in fuel temperature due to wing heating.

Pulsation and shock wave at the diffusor entrance

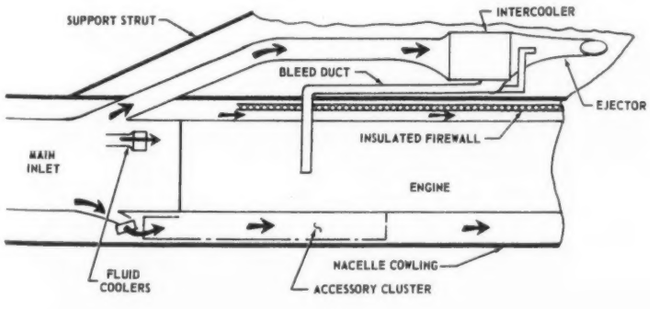
As speeds were raised from subsonic to supersonic, both aircraft and engine designers realized that the hitherto conventional air intakes for jet engines were no longer adequate, since they produced either break-away of the air flow or pulsation which led to engine flame-out or compressor stalling. The problem thus was to find a new geometry for the air intakes, while at the same time designing a system of variable regulation as a function of speed and ensuring that this system would operate automatically. Countless measurements were made in eight different wind tunnels, and close collaboration was established between Convair and General Electric, the former supplying the operational parameters (speeds, altitudes, angles of incidence, power required, etc.), and the latter checking the behaviour of its engine under these various conditions.

On the engine side, a secondary air circuit had to be designed, to cool the lubricants, hydraulic fluid, cabin pressure air, ventilation system for the engine nacelles and the accessories they contain, etc. But, since bleeding off the necessary air also had an effect on the shape of the main diffusor, the two systems were integrated. In the course of time substantial modifications were made in many details. For example, it was found necessary to compensate the marked negative pressure in the main inlet duct when standing on the ground, during take-off and in low-speed flight. For this purpose a cooling door was fitted in the secondary air circuit in the outer nacelle wall, through which outside air enters the secondary circuit during flight below Mach 0.6. Part of this air flows through the coolers in the opposite direction, thus restoring a certain dynamic equilibrium at the diffusor entrance.

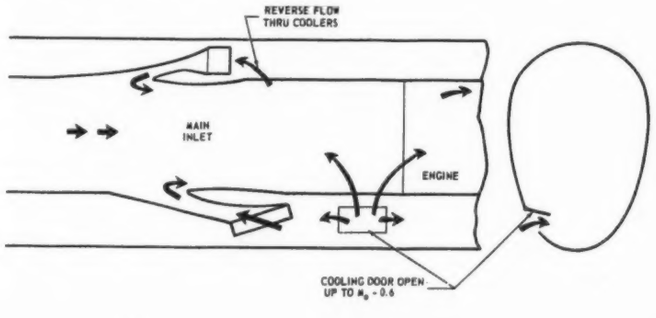
The special conditions under which the *Hustler's* jets operate had unforeseen consequences. It was found possible, for example, to eliminate the conventional firewall normally fitted behind the engine compressor, as the operating temperatures of the compressor housing and the bleed manifold are almost as high as those of the combustion chamber and turbine housings. In addition the firewall had the disadvantage of creating cavities in which hot liquids could accumulate. Instead, fire hazard was reduced by straight-through ventilation of the nacelles. This type of cooling also has the advantage of improving engine performance by permitting a higher operating temperature.

The *Hustler's* armament is of course secret. In view of the large number of different missions on which the aircraft could be used, it may be supposed, however, that Convair has provided for the addition of containers to suit the task to be performed: nuclear weapons, air-to-air missile containers, radio and radar jamming equipment, etc. The electronic equipment has been under exhaustive test for nearly two years in a number of flying test beds, including the B-36, B-47, F-89 and C-131B. Also, it is known that the total funds allocated

Secondary air flow for the J-79 turbojet.



Cooling on the ground and in low-speed flight.



for development up to the pre-production stage have been divided up as follows: 38% for the airframe (the engines are supplied by the Government), 17% for accessories and non-electronic equipment, and 45% for the electronics industry, which thus gets the lion's share of the total.

Convair is also silent on the subject of operational performance. With a total maximum thrust of around 64,000 lbs., the *Hustler* should be capable of attaining speeds corresponding to Mach 1.7 or 1.8 at altitudes above 40,000 ft. Without in-flight refuelling it must be classified as a medium-range type. It seems that it reaches greatest efficiency at high supersonic speeds and that its operational range performance is calculated at speeds of the order of 950 to 1,100 m. p. h.

The U. S. Air Force has ordered a pre-production batch of 13 *Hustlers*. The introduction of a multiple weapons system necessitates long and costly trials, and it is reported that some hundred million dollars a year are being spent on perfecting the B-58 formula.

One aircraft, two philosophies

In revealing to the members of the Society of Automotive Engineers some of the problems encountered in the design of a supersonic bomber, C. J. Martin Jr., of Convair, went further than merely giving facts. His paper revealed two major principles, one industrial, the other military.

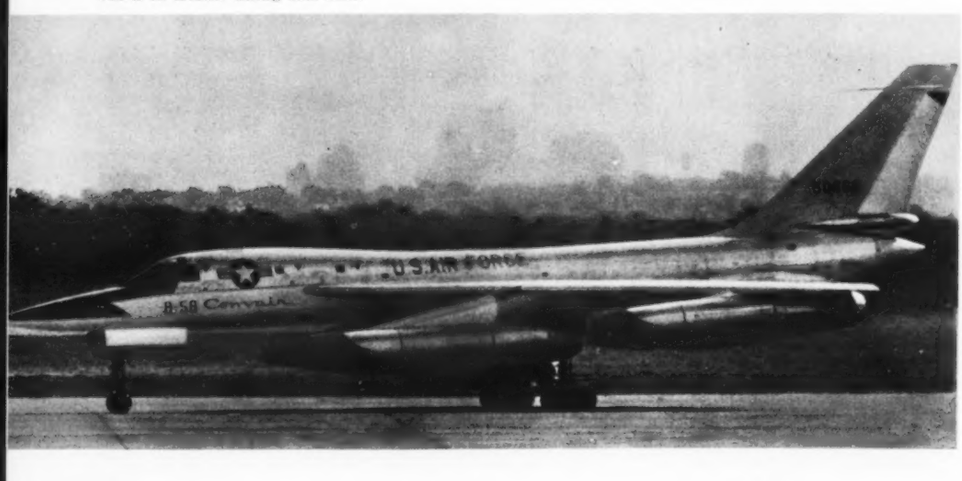
On the industrial side, Convair illustrates the weapons system concept. The day when the airframe manufacturer was required to meet to the best of his ability a set of stringent specifications prepared by the future user—i. e. the military—seems to be past. At one time he had to make the best of the products of the engine and electronics industries, without himself originating designs in these fields. Today, although the various contributions to the finished aircraft remain specialized, the airframe design office has become the coordinator of a vast assembly of scientific and technical activities. Moreover, the designer's responsibilities have substantially increased not only in the technical and industrial fields but also on the operational side. Even in the B-47, Boeing engineers' contribution to operational efficiency had been considerable, because of the aircraft's complexity and its extreme sensitivity to various operating conditions. This trend has since become increasingly marked with the constant improvement in performance. The aircraft itself has become no more than a link—though the essential link—in a vast chain of interconnected techniques. In the case of the B-58, the result is an instrument capable of launching a given number of nuclear projectiles over a given range and at supersonic speed, while at the same time providing the maximum protection for the aircraft in the accomplishment of its mission and bearing in mind the physiological limits of the crew that is still required to operate it. This combination of many different elements, each closely linked with the others, can produce a militarily efficient instrument only if each plays its part with the utmost reliability, since a failure in one cancels out the advantages of the whole weapons system. To ensure the success of this vast four-fold undertaking (military, scientific, technical and industrial), a new form of organization, which the U. S. Air Force was intelligent enough to accept, had to be created, with Convair holding the strings to control a multiplicity of different scientific and technical activities.

For his part, the future operator is more concerned with the object to be achieved than with laying down the methods of achieving it. In the case of the *Hustler*, the task of both military planner and engineer was especially complicated since the weapons system concept was not confined to a single type of mission but widened to cover a number of different functions which interacted upon one another. Whatever its military success as a weapons system may be, the B-58 *Hustler* project is clearly the outcome of a tremendous intellectual effort in the field of aircraft design philosophy for tomorrow.

Like the Lockheed F-104 and other similar projects, the Convair B-58 undoubtedly necessitated the provision of a vast staff and a large collection of computing, experimental and testing equipment. The prime contractor is obliged to organize subsidiary technical groups around his original design office and hence to enlarge his research apparatus. The repercussions of this new trend in the American aircraft industry can be imagined. The industries of other countries scarcely have the means to adopt the weapons system concept in its full implications.

From the military point of view, the fact that the U.S.A.F. should have devoted millions of dollars to the development of the *Hustler* proves that intercontinental range is not its only concern. As a bomber, the B-58 is undoubtedly the ideal instrument for a relatively close-range strategy. However, it would be well not to be too categoric on this point, in view of experience with the B-47, whose endurance was increased to an unexpected extent as development progressed. Nevertheless, it is interesting, at a time when all intellectual and financial efforts appear to be concentrated on achieving intercontinental capability by either aircraft or missiles, to see a weapons system *designed for speed rather than range* appear in the skies above Fort Worth and Edwards AFB. Tomorrow, however, with its weapons system No. 110, the U.S.A.F. may have a machine that will combine intercontinental range with supersonic speed, two aspects of performance that today are still irreconcilable. The Cassandras on this side of the Iron Curtain who forecast a return to American isolationism, and those on the other side who speculate on an American withdrawal across the Atlantic, would do well to meditate on the programme under which the B-58 *Hustler* has been designed and built.

The B-58 *Hustler* during taxi tests.



The U.S.A.F.'s Century Series of Supersonic Fighters

The U.S.A.F.'s supersonic fighters, from back to front: McDonnell F-101A *Voodoo*, Convair F-102A, North American F-100C *Super Sabre*, Lockheed F-104 *Starfighter*.

The age of supersonic flight was opened on October 11th, 1947, when America's Bell XS-1 experimental aircraft first broke the sound barrier. Today, however, nearly ten years later, aviation is still only at the beginning of the new epoch, and it would seem as if even the aerodynamicists' most cautious predictions were not cautious enough. The theoretical problems of flight at speeds around Mach 2 are still by no means solved, a fact of which the authorities which have to provide the funds for research and development are fully aware.

Though many advanced projects have been tackled to meet military requirements, and *research aircraft* with speeds of up to 2,500 m. p. h. have been built, these successes can in no way obscure the difficulties which the designer of *combat aircraft* encounters. His task is to design an aircraft for sustained supersonic flight that is controllable throughout its speed range and can manage with runways of under 7,000 ft. His fighters must be stable and at the same time highly manoeuvrable, gun platforms and be capable of being flown by average pilots. Designers are still puzzling over the best configuration for the various speed ranges . . . and aerodynamicists seem to be in no position to give designers clear-cut directives. In view of these difficulties full credit must be given to the American aircraft industry, which produced the first really supersonic fighter seven years ago and has been building it in quantity since 1953—a fighter which crosses the transonic range in level flight and reaches Mach numbers of around 1.2 at higher altitudes. For the Air Force the age of supersonic flight began with the introduction of the North American F-100 A *Super Sabre* into service.

• North American F-100

The project for this unusual aircraft took shape as long ago as February 1949, at about the time when the North American F-86 *Sabre* went into large-scale production. Later the results of operational experience in the Korean War were incorporated (modified requirements as regards high altitude performance, manoeuvrability, ease of maintenance). The prototype left the assembly shop in April 1953.

Mach 1 was exceeded during the very first flight, on May 25th, 1953, and in September of the same year North American was able to report to the U. S. Air Force that the first F-100 A production model had been completed. To demonstrate the *Super Sabre's* performance capability the U.S.A.F. made a speed attempt on October 29th, 1953, during which Lieutenant Colonel F. K. Everest raised the existing world speed record over a 15-km course to 1,215.298 km/h (755.151 m. p. h.) at sea level. A further confirmation of the F-100's performance was provided on August 20th, 1955, when Colonel H. A. Hanes, Director of Flight Test Operations at Edwards Air Force Base, California, set up a new world speed record of 1,323.312 km/h (822.125) at an altitude of 35,000 ft.

The F-100 was originally planned as a development of the F-86, but as the years went on an entirely new aircraft emerged, with the following main characteristics: 45° swept wing with a thickness/chord ratio of only 6%; low-set all-flying tailplane; aerodynamically stressed fuselage with flat belly and streamlined top with very flat cockpit canopy; sharp-lipped air intake for the Pratt & Whitney J-57 jet engine.

The J-57 is a two-compressor engine with nine low-pressure and seven high-pressure stages, which has very flexible performance characteristics and is thus particularly suitable for high altitude flight. It can be accelerated from standstill to full revs. (9,400 r. p. m.) in roughly 10 seconds—a decisive safety factor in air combat and during landing approach. Both jet engine and afterburner are automatically regulated by operation of a single power control, which prevents the pilot from exceeding the critical engine speed in a dive or overloading the engine by opening the control too rapidly. Considerable difficulties were encountered in the design of the air intake duct, which on the one hand must have the sharp inlet edges required for supersonic flight, while on the other hand both stalling in the inlet and surging in the compressor must be prevented during high altitude or slow flight with high angle of attack. Measures taken to avoid such disturbances include provision of air flow channels from the inlet to the fuselage sidewalls and a narrowing of the section shortly in front of the compressor face.

American pilots making a public demonstration of the F-100C at the U.S.A.F.'s Bitburg base in Germany were warm in praise of the *Super Sabre's* flying qualities. They remarked that pilots with only 50 hours flying on any swept-wing type can normally master the heavy fighter after only 10 conversion hours. They do, however, have to accustom themselves to certain peculiarities in the transonic region, such as a reduction in longitudinal stability and slight trimming difficulties. In an effort to overcome these disadvantages the vertical fin was modified several times, at first being made smaller and later considerably bigger. Yet even the latest models do not seem to be entirely satisfactory as regards longitudinal stability at high angle of attack and high altitude.

To ensure that the F-100 would be a stable gun platform, elevators and rudder were from the start equipped with pitch and yaw dampers respectively. In view of the wing loading of approx. 86 lbs./sq. ft. (based on the net wing area) the use of power-controlled Handley Page slots was found to be essential in turns

F-100C with slots open for a fighter-bomber mission. Military loads totalling more than 2 ½ tons can be carried beneath the wings.

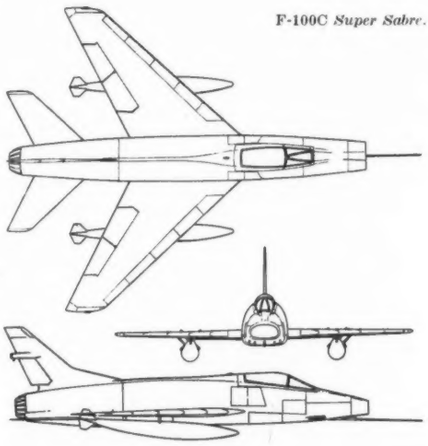
Keep away! A *Super Sabre's* afterburner spewing flames into the night.

and during landing approach. These lift aids, already successfully used in the F-86, are said to make the F-100 at least equal to Britain's Hawker *Hunter* jet fighter as regards manoevrability. The latter quality is also undoubtedly helped by the high thrust of the Pratt & Whitney jet (17,000 lbs. with afterburner). The results of earlier N.A.C.A. flight research had already revealed that an increase in lift in the transonic and supersonic ranges—i. e., in tight turns—entails an incomparably greater increase in drag than in the subsonic range. In other words, with the inevitable high wing loading in supersonic flight, adequate manoeuvrability can be obtained only with a substantial power surplus, compared with the thrust required for straight flying.

Though, with afterburner operating, the F-100 has the required thrust reserve, use of the afterburner must be limited to a few minutes because of its high consumption. Without reheat the J-57 has a specific fuel consumption of 0.77 lbs./lb.t./hr. With afterburner operating, this figure rises to 1.8 lbs./lb. t./hr., or nearly 4,500 U. S. gallons per hour near the ground, whereas the F-100's total fuel capacity, for a gross weight of 25,000 lbs., is only 1,195 U. S. gallons. Use of the afterburner will therefore depend to a large extent on the operational mission. Nevertheless, the F-100 can climb to 36,000 ft. in four minutes by using the afterburner for a brief period during the first phase of the climb.

The aerodynamic peculiarities of the swept wing made it necessary to move the ailerons further inboard. This meant that conventional landing flaps on the wing trailing edge could not be fitted, so that the F-100 lands with a large angle of attack and at a speed of around 155 m. p. h. To keep the landing distance within acceptable limits, therefore, standard equipment includes a brake parachute, which, however, may not be used until immediately before touchdown.

The F-100's armament comprises four 20-mm type M-39 cannon, housed in an easily serviced bay underneath the cockpit and fed with 200 rounds of ammunition each from magazines above them. Gunsight is the A-4 radar sight which was thoroughly proven in the F-86. The navigation and fire control radar included in later fighters of the Century series are not fitted, which suggests that the F-100 was designed less for defence against long-range bombers than for operations against enemy fighters and tactical bombers. External stores (to a total weight of 5,700 lbs.) that can be carried in special containers beneath the wings include auxiliary fuel tanks, up to eight bombs, 3-inch *Mighty Mouse* unguided rockets, 5-inch guided rockets, or napalm containers.



F-100C *Super Sabre*.

The F-100 is in production at North American Aviation Inc.'s main plant at Los Angeles and the subsidiary plant at Columbus, Ohio. The latter turns out F-100C and F-100D versions. Production of the F-100 also raised new problems, such as, for example, the shaping and machining of titanium and the provision of giant planing and horizontal milling machines for shaping the wing plates. These integrally stiffened aluminium plates span roughly 16 ft. and are 1 ¾ ins. thick at the wing root. Whereas the wing box in the F-86 was composed of 462 pieces and more than 16,000 fasteners, the F-100's wing box uses only 36 pieces and 264 fasteners. On the other hand, the tolerances required are so fine that normal temperature changes in the plant in the course of a day cause unacceptable changes in the dimensions in tools and material. Critical components, such as wing plates, therefore, have to be manufactured in air-conditioned shops.

• McDonnell F-101

Designed only a little later than the F-100, the McDonnell F-101 *Voodoo* twin-jet supersonic fighter is destined for Strategic Air Command and is equipped for the following tasks: escorting very high-flying long-range bombers, photographic reconnaissance in the enemy's rear, dropping of atomic bombs on enemy supply centres and arms installations. The F-101 was developed in essentials from the XF-88 experimental twin-jet type, the development of which was suspended—despite the prototype's promising performance—because of changes in the U.S.A.F.'s specifications. According to unconfirmed reports, the maximum load factor of its extremely light fuselage would not have stood up to the exigencies of ground attack operations. The present version of the supersonic fighter took shape on the drawing board in 1951, and in January 1952 McDonnell received a sizeable production contract and appropriations totalling $ 20,000,000 for the construction of a strategically protected production plant at St. Louis, Mississippi. The first F-101 A's were delivered to Strategic Air Command at the end of 1956.

With the exception of the two engines in the rear of the fuselage, the McDonnell fighter does not immediately suggest that it is capable of high supersonic speeds. The unusually long and spacious fuselage provides a fuel capacity of at least 2,000 U. S. gallons, so that if the second engine is cut off from time to time the F-101 has a range of "over 2,000 miles" without auxiliary tanks. As, in addition, up to three

supplementary tanks can be carried, and all *Voodoos* are equipped for in-flight refuelling, the full range of this escort fighter and A-bomb carrier probably approaches that of a medium-range jet bomber. Admittedly the relatively small wing area and a gross weight of roughly 44,000 lbs. produce a wing loading that hardly promises the manoeuvrability of a conventional jet fighter, even with the aircraft's high power surplus with afterburners operating (a total of 29,000 lbs.). At any rate an aircraft operating at great altitudes with a take-off wing loading of approx. 146 lbs./sq. ft. can no longer be regarded as a fighter in the traditional sense.

The F-101's armament comprises four 20-mm cannon (two on either side of the fuselage), three Hughes *Falcon* guided missiles and several groups of *Mighty Mouse* unguided rockets, the latter all housed in a bay with retractable launcher underneath the fuselage.

Unlike the F-100, all versions of the F-101 have large landing flaps on the underside of the inner wings; no slots are fitted. Air brakes on either side of the rear fuselage, both of which can be operated throughout the speed range, and a brake parachute stowed in the tail cone are provided to reduce the otherwise excessive landing run. The flaps can also be used as air brakes in high-speed flight, without causing any appreciable change in load distribution. The angle of the high-set all-flying horizontal tailplane can be varied through a total of 45° and, like the rudder, is coupled with a flight path oscillations damper. The inevitable falling off in the effectiveness of the tailplane and rudder at increasing Mach number is compensated, as in the other Century fighters, by the generous dimensions of the tail surfaces. As is known, the dynamic stability of a swept wing deteriorates considerably in supersonic flight, particularly at high altitudes, with the appearance of superimposed rolling, yawing and pitching oscillations which can be kept within manageable limits only by fitting automatic stabilization aids. N.A.C.A.'s flight research programme had shown that the distribution of masses in relation to the direction of flight has a decisive influence on stability. The presumed reason for this lies in the combination of masses which becomes particularly critical when the aircraft's main masses are distributed along the fuselage, as is the case in the F-101. In such a case any motion originating about one axis gives rise to disturbing motions about the others, for example undesirable yawing and pitching motions during a roll. All these conditions had to be investigated by McDonnell in painstaking detailed experiments and protracted flight testing, before the $2,000,000 fighter could go into production.

In November 1955 the U.S.A.F. received the first *RF-101A photographic reconnaissance aircraft* for operational testing. An undisclosed number of these aircraft is under construction for the Strategic Air Command. The RF-101A is equipped with a television viewfinder for the pilot and a set of fully automatic cameras and has a longer fuselage nose with an oblique camera window. Photographs can also be taken at night with the aid of high-intensity flashes and special cameras. This photographic reconnaissance version of the *Voodoo* carries the most extensive navigation equipment ever to be built into a single-seat aircraft. The latest known model of the *Voodoo*, the *F-101B long-range interceptor*, is in production for the U.S.A.F.'s Air Defense Command. Since the beginning of 1952 McDonnell has received U.S.A.F. contracts to a total of $330,000,000 for the various versions of the F-101, not including spares, maintenance equipment and training material.

• Convair F-102

An entirely different approach was chosen by the Convair Division of General Dynamics Corporation. Convair's answer to a U.S.A.F. specification for a supersonic all-weather fighter with extensive electronic equipment and an endurance of at least one hour, is the F-102 delta-wing design. Wind tunnel experiments showed that the delta wing had better drag behaviour than the swept wing in the transonic range, as well as at low supersonic speeds, and promised a better centre of pressure travel during passage through the sonic barrier. As so frequently happens, however, an advantage on one side had to be paid for by disadvantages on the other. One such disadvantage is that the delta wing is extremely sensitive to changes in the centre of gravity, since the elevons on the wing provide only limited trimming. Thus if the same degree of longitudinal stability is required of a delta-wing aircraft as of swept or straight-wing types, the maximum permissible angle of attack has to be greatly reduced.[1] In addition a delta-wing aircraft experiences less efficient damping of pitching oscillations than a conventional aircraft in the transonic range, which necessitates the use of automatic stabilization aids. Because of the limited effectiveness of the elevons (combined elevators and ailerons), the maximum lift coefficient in the delta aircraft is lower than in conventional configurations, though this is compensated to a certain extent by the larger wing area.

After weighing all factors Convair finally arrived at the configuration of the XF-102 prototype, which, however, with the power then available in the J-57 jet engine, did not manage to exceed Mach 1 even with afterburner. The main reason was the excessive

[1] *Cf. Interavia* No. 1, 1953, pp. 23, etc.

In-flight refuelling of an F-101A *Voodoo* long-range fighter by the flying boom system. The tanker aircraft is a Boeing KC-97.

Long nose, triangular air intakes, two jets in the fuselage rear... the single-seat RF-101A photographic reconnaissance version.

interference drag between the wing and the fuselage[2]. After design of a new, slenderer fuselage which followed the area rule elaborated by N.A.C.A. scientists, and after further modifications to the delta wing, the improved F-102A version (production model) finally reached the desired speed.

Combat with fast, high-flying enemy aircraft is facilitated by a Hughes automatic fire control system. Once this system has manoeuvred the fighter on to the most favourable lead course, a container with several Hughes *Falcon* guided missiles is automatically lowered from the fuselage belly, the missiles are fired at the correct moment by the fire control system and guided to the target. No ordinary cannon are carried. The unit price of the first thirty production aircraft worked out at no less than $1,300,000.

A few months ago the U.S.A.F. awarded a $83,000,000 contract for production of the *F-102 B all-weather fighter* with Pratt & Whitney J-75 engine. This version has recently been given the U.S.A.F. designation F-106A and has been fitted with a larger wing, presumably to obtain better altitude performance.

• Lockheed F-104

The most revolutionary American fighter design is undoubtedly the Lockheed F-104 *Starfighter*, a "light-weight" model weighing roughly 17,500 lbs. for top speeds of around Mach 2. The negative dihedral wing halves measure only 8 ft. from the 22 ft. fuselage. The 16,500 lbs. static thrust (with afterburner) of the General Electric J-79 equals the fighter's weight, and the extremely high take-off wing loading of more than 150 lbs./sq. ft. (in relation to the net wing area) must scare even the most hardened pilot. Landing run will probably exceed the runway length at N.A.T.O. air bases. Landing approach speed is probably around 250 m. p. h., and touchdown speed, even at a generous estimate, at least 175 m. p. h.

That this "manned missile" is still more or less controllable is due to a power-boosted control system with automatically regulated limitation of control surface travel and the Lear 3-axis stabilizer which remains in operation throughout the flight. Aerodynamic aids such as wing leading and trailing edge flaps increase the wing's maximum lift coefficient from 0.65 (normally) to 1.3 or 1.4.

The wing unit consists of two separate half wings of roughly 3% thickness/chord ratio, which are attached to the fuselage side walls, thus leaving the interior of the fuselage free for the engine. The wings, parts of the fuselage and the tail unit are of steel. Another interesting detail is that the air intake ducts are equipped with conical multi-shock diffusors which give a theoretical pitot head utilization of around 90%. The F-104A is the first production aircraft to have a downward-type ejection seat. The cockpit canopy is opened and shut by hand.

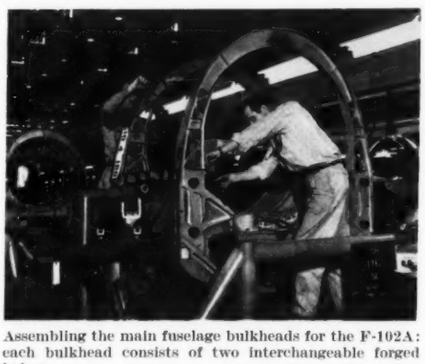
[2] Cf. *Interavia* No. 12, 1955, pp. 928, etc.

Instructor and student climb into a Convair TF-102A supersonic trainer. The air intakes had to be substantially modified by comparison with the single-seat version.

Asked about the F-104's unusual configuration, Lockheed Chief Engineer C. L. (Kelly) Johnson made the following points: though low-aspect-ratio wings are not aerodynamically desirable, very thin wings with a higher aspect ratio cannot be built, for strength reasons. A low thickness/chord ratio is essential, however, for supersonic flight. A wing of 3% thickness/chord ratio, for example, has only 63% of the drag at Mach 1.5 of a comparable wing of 5% ratio. Some years ago Lockheed had worked out a project for a supersonic fighter with a delta wing, but had come to the conclusion that a straight wing of moderate aspect ratio was preferable for high supersonic speeds, in particular because of its more favourable lift coefficient in low-speed and high-altitude flight and its better lift/drag ratio. Delta aircraft are liable to land hard, which necessitates extra long shock absorbers and hence additional weight.

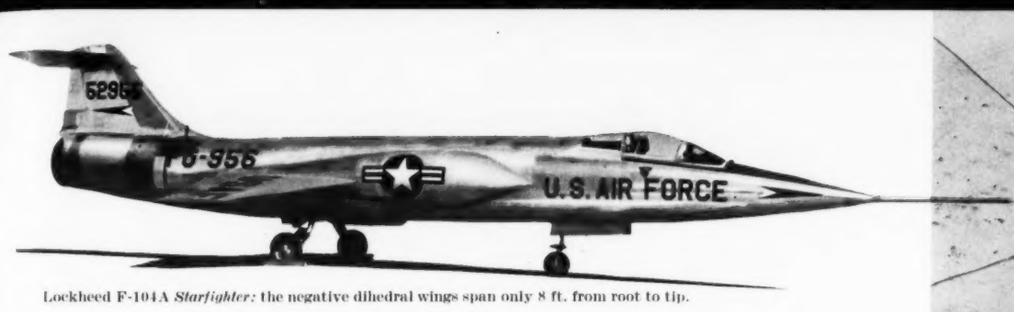
Johnson explained the choice of a negative dihedral for the wing (approx. 10°) as follows: "This stems from the combined effects of having a wing that extends only 8 ft. from the fuselage and a tail fin that reaches almost the same distance in a vertical direction. Because the vertical tail had the span of a wing, the deflection of a rudder acted like an aileron. To compensate for the roll you get from the vertical tail, we put the negative dihedral in the wing." The mid-wing configuration, he added, had enabled drag to be reduced by 12% compared with a low-wing aircraft of similar dimensions. De-icing problems are virtually non-existent because of the very small radius of the wing and tail leading edges (sixteen thousandths of an inch). As the thermal rise at the aircraft's high speed would melt any ice which did form on the basic structure, there was no need to fit special de-icing devices.

Although no official information is available on the F-104's armament, it is reported in American aviation circles that the *Starfighter* carries a new six-barrel revolving cannon of unusually high rate of fire. The 20-mm cannon in question is electrically or hydraulically controlled and was developed by General Electric Company, which started on the project in 1946. The present version bears the designation T-171 *Vulcan*. Its six barrels are arranged symmetrically in a common rotating drum housing. As the barrels fire in sequence, a very high rate of fire is possible without overheating. Length is 72 ins., and total weight approx. 300 lbs. The cannon is evidently

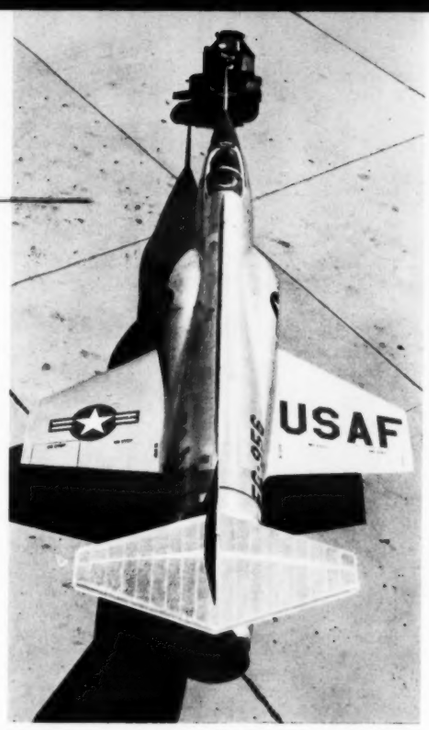


Assembling the main fuselage bulkheads for the F-102A: each bulkhead consists of two interchangeable forged halves.

Convair F-102A: downward curving wing leading edge to improve high altitude and low-speed characteristics.



Lockheed F-104A *Starfighter:* the negative dihedral wings span only 8 ft. from root to tip.



mounted underneath the fuselage, slightly offset from centre, between the undercarriage bays.

• Other Century fighters

The supersonic fighters so far discussed have all been types that are already in squadron service or on which adequate data and photographic material are available. Very little information has been released on the other aircraft of the Century series, so that their description will have to be postponed to a later issue. The following is therefore merely a brief résumé of such details as are already known.

The *Republic F-103,* an interceptor with delta wing, was cancelled from the U.S.A.F. programme about a year ago. It is not known whether the prototype was completed and test flown. Powered by a Wright J-67 turbojet (licence version of the Bristol *Olympus)* of roughly 10,000 lbs. thrust and a ramjet of undisclosed type, the F-103 was designed to engage high-flying adversaries in a supersonic climb: span approx. 25 ft., length approx. 55 ft., gross weight approx. 20,000 lbs.

Republic Aviation Corp.'s Farmingdale plant is producing the highly secret *F. 105 B Thunderchief supersonic fighter-bomber.* With its Pratt and Whitney J-75 engine plus afterburner, it is reportedly capable of speeds around Mach 1.5. It has an extremely thin wing of low aspect ratio and a long cylindrical fuselage designed according to the "extended area rule". The air intakes are in the wing roots on either side of the fuselage. The tail consists of a low-set all-flying horizontal stabilizer, a fin with rudder on top of the fuselage and another fin underneath the fuselage, probably designed to improve longitudinal stability at high angles of attack and at altitude. According to reports six pre-production aircraft are being flight tested.

A rival development to the Republic F-105 is the North American *F-107 supersonic fighter-bomber,* an improved version of the F-100 *Super Sabre* powered by a Pratt & Whitney J-75 jet. According to the "Los Angeles Times", one of the prototypes several times reached twice the speed of sound during test flights in November 1956. Although the U.S.A.F. has cancelled the production contract for this type for undisclosed reasons, testing of the three prototypes is continuing.

*

Finally, it should be mentioned that almost all the Century series supersonic fighters have also been built in a two-seat trainer version. For example, the *two-seat F-100 F version* of the *Super Sabre* has completed its first test phase and is now in production. Despite its longer fuselage (seats in tandem), it is said to be in no way inferior in performance to the standard fighter. Convair is building the *two-seat TF-102 A* with side-by-side seats, wider fuselage and modified air intakes. Though designed primarily for training pilots for the Convair F-102 A fighter, it could also be used for tactical operations against ground and air targets. Two-seat trainer versions have also been developed of the Lockheed *Starfighter* and most probably of the Republic F-105B. A production contract for the *two-seat F-104 B* was awarded a few weeks ago.

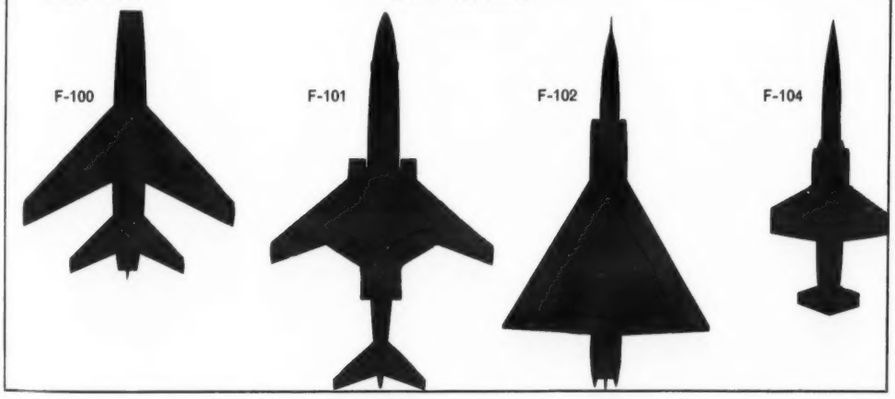
*

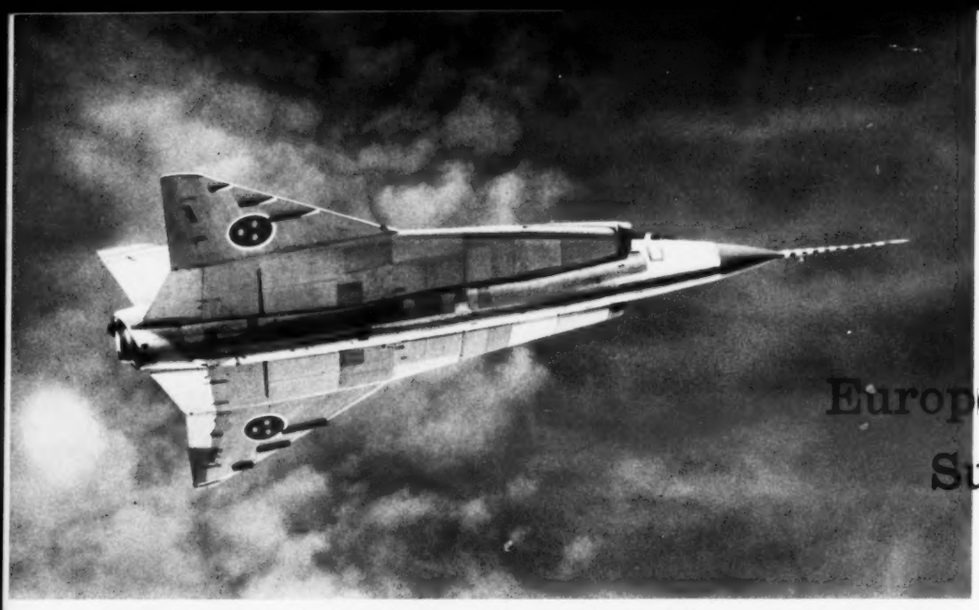
If the development of the Century series runs according to plan, the United States will maintain its lead in fighter development—despite the fears of certain Congressmen—while at the same time laying the foundations for tomorrow's pilotless fighter.

Technical Data of U. S. A. F. Supersonic Fighters

Type	F-100C	F-101A	F-102A	F-104
Power plant	1 × P&W J 57-P-21	2 × P&W J 57-P-13	1 × P&W J 57-P-23	1 × G.E. J 79
Thrust without reheat (lbs.)	12,000	2 × 11,000	12,000	app. 12,000
Thrust with reheat (lbs.)	17,000	14,500	17,500	16,500
Span (ft. ins.)	38′	39′ 7″	38′ 2″	22′
Overall length (ft. ins.)	47′	67′ 5″	68′ 3″	54′ 9″
Sweep	45°	35° *	60° **	20° *
Net wing area (sq. ft.)	290	300	475	116
Thickness/chord ratio (%)	6	6—4.5	4	3
Aspect ratio (span: mean chord)	4.05	4.48	2.56	2.97
Gross weight (lbs.)	25,000—28,500	44,000	35,000	17,000—18,000
Fuel capacity normal (U.S.gals.)	1,195	app. 2,400	app. 1,350	—
Fuel capacity max. (U.S.gals.)	1,745			
Max. Mach No. in level flight	1.25	1.3—1.4	app. 1.4	2.0
Range normal (miles)	1,000	2,000+	1,250+	800
Range max. (miles)	app. 1,350			app. 1,350
Take-off wing loading (lbs./sq. ft.)	86—98	146	74	146—155
Wing loading at dry weight (lbs./sq. ft.)	60	94	55	—
Power loading (lbs./lbs. thrust)	1.5—1.7	app. 1.5	app. 2.0	1.02—1.1
Armament	4 × 20 mm M-39 Air-to-air or air-to-surface rockets	4 × 20 mm M-39 3 Hughes Falcon	4 × 20 mm M-39 3 Hughes Falcon	1 × 20 mm T-171 Guided missiles of undisclosed type

* at 25% chord. ** leading edge sweep.





European Supersonic Aircraft

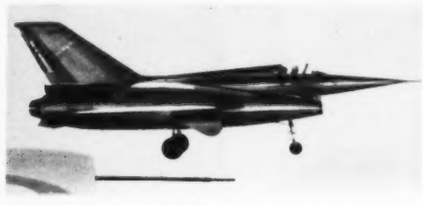
Svenska Aeroplan Saab-35 (J 35) Draken (Sweden): Single-seat all-weather fighter with double-delta wing, which began flight testing in October 1955 and is now in production. Fitted with a Rolls-Royce (Svenska Flygmotor) *Avon* engine, the J 35 weighs between 17,600 and 19,800 lbs., has a span of approx. 35 ft. and a length of approx. 50 ft., and can carry guided missiles. (Cf. also *Interavia* No. 11 and No. 12, 1956.)

Fairey FD.2 (Great Britain): Although a pure research aircraft, the FD.2 is included in the present list as holder of the world speed record (1,132 m.p.h. = 1,821 km/h). Powered by a Rolls-Royce *Avon* plus reheat; extremely thin delta wing with roughly 60° leading edge sweep; span 26 ft. 10 ins., length 51 ft. 7.5 ins. First flight by first FD.2 in October 1954; the second FD.2 flew for the first time in February 1956.

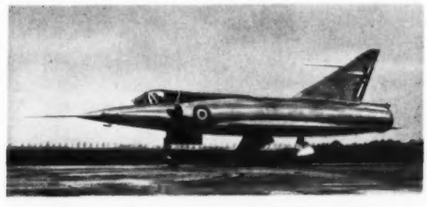
Sud-Est Aviation SE.212 Durandal (France): Light interceptor with delta wing, powered by a SNECMA-ATAR 101 G afterburner jet and rocket motor. First flight in April 1956.

Ouest Aviation SO.9050 Trident II (France): Light, single-seat interceptor, which began flight testing in July 1955. Powered by two relatively low power jets and a SEPR Type 631 rocket motor. The jets can be either Dassault MD.30 *Vipers* or Turboméca *Gabizos* (with or without afterburner). The SO.9050 features relatively great operational flexibility and can be operated from roughly prepared bases of comparatively small dimensions. — Span 22 ft. 8 ins., length 42 ft. 8 ins., wing area 156 sq.ft., gross weight 11,350 lbs.

Vickers-Supermarine N.113D (Great Britain): Single-seat carrier-based fighter, ordered in substantial numbers and now in production, to replace the older Hawker *Sea Hawk* in the Fleet Air Arm. First flight in January 1956. Fitted with two Rolls-Royce *Avon* jets. — Span 37 ft. 2 ins., length 55 ft. 4 ins. — First N.113D armed with four 30-mm Aden cannon; later models to carry guided missiles.

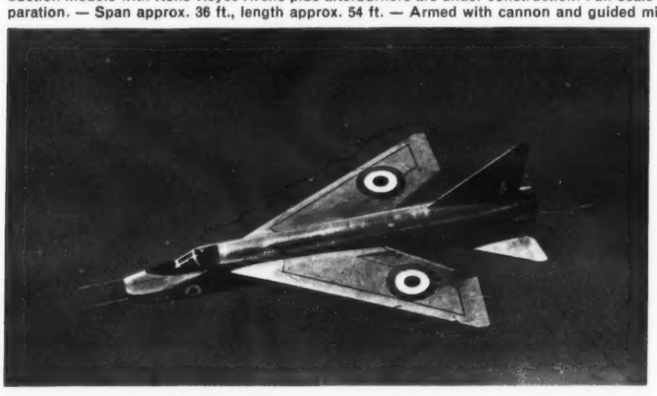


Nord 1500 Griffon (France): A supersonic light-weight interceptor built by S.N.C.A. du Nord, which in its present form is fitted with a turbojet plus afterburner, the latter apparently acting as ramjet at high speeds.

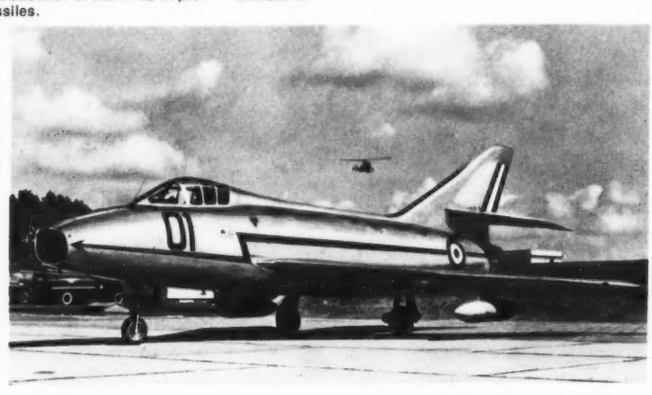


Dassault Mirage III (France): Light-weight interceptor built to the area rule, with SNECMA-ATAR 101 G jet including afterburner (approx. 9,920 lbs. thrust). The *Mirage III*, which began flight testing on November 17th, 1956, will be capable of carrying a guided missile underneath the fuselage.

English Electric P.1 (Great Britain): First British fighter developed for supersonic speed in level flight. The first prototype, P.1A, began flight testing in August 1954. Since then a second prototype has also flown, while a third P.1A has been built for static load tests. The P.1A prototypes are powered by two Armstrong-Siddeley *Sapphire* jets. Twenty pre-production models with Rolls-Royce *Avons* plus afterburners are under construction. Full-scale production of the P.1B in preparation. — Span approx. 36 ft., length approx. 54 ft. — Armed with cannon and guided missiles.



Dassault Super Mystère B.2 (France): Production single-seater which can be used either as interceptor or in support of ground fighting. Fitted with SNECMA-ATAR jet plus afterburner.



Technical Problems of Supersonic Flight

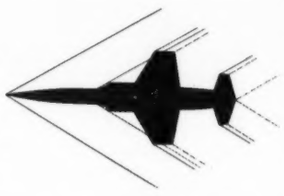
The sole object of the following "primer of supersonics" is to sketch the most important problems of flight beyond the speed of sound (approx. 760 m.p.h. near sea level; 650 m.p.h. in the stratosphere) in readily understandable form and to outline briefly the methods of solving them. A great deal more could, of course, be written on each of these problems than can be compressed into the small space available. It must also be stressed that none of these questions can be considered in isolation, since all are closely interdependent. Above all, airframe and power plant form an inseparable whole in a supersonic aircraft, since any modification in airframe configuration affects the power plant's thrust surplus over drag, and every change in power plant performance or design influences airframe configuration.

Why is it so difficult to fly faster than sound? According to Professor von Karman* "it is a question of flying faster than any pressure effect produced in the air can be propagated". At high flying speeds the air must be regarded as a "compressible fluid", and the simple formulae of conventional aerodynamics are replaced by the complicated laws of "aerothermodynamics". Disturbances, such as control surface deflections, now act only rearwards, within a "Mach cone" that becomes more and more pointed as speed increases. And the extremely thin, membrane-like "skin" of this cone (only one ten-thousandth of an inch thick) radically modifies the speed, direction, pressure and temperature of the air flow passing through it.

* "Aerodynamics", p. 104. Cornell University Press, New York. French and German translations published by Interavia S. A., Geneva, Switzerland.

1. Aerodynamic airframe configuration

1.1 Every object flying in the transonic and supersonic ranges produces compression and expansion waves in the air and thus experiences high additional drag. This **wave drag** depends on the configuration and size of the object and is particularly great when the shock waves strike portions of the surface downstream. In the ideal case of a spindle tapered at each end (or a flying wing) it increases proportionally with the square of the ratio between diameter (thickness) and length (wing chord).



Plan of the Lockheed F-104 Starfighter.

SOLUTION : The aircraft's frontal section—including wings—is kept as small as possible, which leads to high area and span loadings (more than 150 lbs./sq. ft. and 800 lbs./ft. respectively). On the other hand, very long fuselages are chosen, and shock wave interference is avoided.

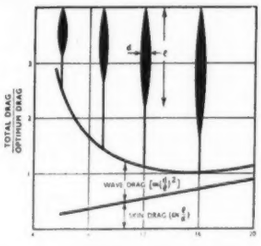
1.2 The most important single problem is the design of the wing and tail surfaces as regards **sweep, aspect ratio and airfoil section.**

SOLUTION : On the basis of the design Mach number (at which the aircraft is to attain its optimum qualities), the designer chooses a swept or delta wing for low supersonic speeds, and a straight wing for high supersonic speeds (above M = 1.8). Angle of sweep must be adapted to the Mach cone angle (130° for M = 1.1, 60° for M = 2 etc.), thickness/chord ratio kept in every case as low as (structurally) possible (see picture). Uncambered (symmetrical) laminar airfoils with rounded leading edge (up to approx. M = 1.5) or sharp leading edge (above M = 1.5) are the rule.

The Lockheed F-104's slightly swept trapezoidal wing has a thickness/chord ratio of only 3%.

1.3 Choosing the dimensions for the fuselage and the engine nacelles on the basis of a given cross section area encounters the **problem of total drag** (wave plus skin drag). Increasing spindle length reduces wave drag, but increases skin drag (see diagram).

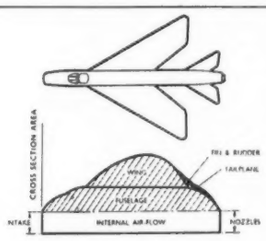
SOLUTION : Aim is the optimum solution (fineness ratio approx. 1:16), but structural weight (possible reduction in optimum fineness) and space for fuel (possible increase) must also be considered.



Drag of supersonic spindles plotted against fineness ratio (from R.F.Creasey).

1.4 If the overall design of the aircraft is defective extreme **drag rises occur in the transonic range** which can prevent or postpone attainment of the design Mach number.

SOLUTION : The distribution of the aircraft's cross section areas (along the longitudinal axis) is matched as closely as possible to the distribution in a body of rotation with both ends pointed (the "area rule"). It is, however, essential that the actual aircraft should (1) be slender, and (2) have an extremely smooth surface.



The English Electric P.1 ideally meets the area rule (from R.F.Creasey).

1.5 Because of their low aspect ratio and sharp leading edges, typical supersonic aircraft have very much higher **induced drag** (i. e., drag due to lift) between Mach 0.3 and approx. Mach 2 than less radical designs. This drawback becomes more marked when the wing receives an additional load from powerful downwards forces acting on the tailplane (so-called "trim drag") and is particularly critical in turns.

SOLUTION : These disadvantages are alleviated by compromises in the wing shape (for example, swept wings are better than delta wings) and in the span loading (larger span for the same gross weight), depending on the mission. In every case the tail unit's lever arm must be as big as possible.

McDonnell F-100 Voodoo: compromise in wing shape; longer tail unit arm.

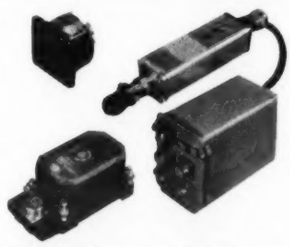
1.6 Above Mach 0.8 **control efficiency** begins to fall off sharply, owing to the fact that all upstream surfaces are no longer aerodynamically influenced by control surface deflections. At the same time control surface hinge moments and stick forces continue to grow as speed increases.

SOLUTION : Aircraft are equipped with large "all-flying" tailplanes and large rudders and ailerons, all of which must be actuated by irreversible power controls. A skilful system of artificial feel, which makes allowance for "q-feel"—and hence altitude—and Mach number, is desirable.

All-Flying tail in the North American F-100 Super Sabre.

1.7 As a result of unilateral distribution of masses (primarily in the longitudinal direction) and powerful aerodynamic interactions, typical supersonic aircraft have a tendency towards **dynamic instability.** Any motion about one axis can lead to undesired motions about the other two axes.

SOLUTION : To assist the pilot, gyro-controlled servos are built into the power control system, at any rate to eliminate yaw oscillations and if possible to remove roll and pitch oscillations (e. g. the Lear 3-axis stabilizer).



Yaw oscillations damper (with gyro, servo-motor, regulator and amplifier) made by S.F.E.N.A., Neuilly-sur-Seine.

1.8 The configuration chosen to give the design Mach number in high-speed flight generally impairs the stability and controllability of the supersonic aircraft in **slow flight,** particularly during take-off and landing.

SOLUTION : An improvement can be obtained by fitting leading edge flaps or power-controlled slats and by moving the ailerons further inboard (in swept wings only), but extensive wind tunnel tests to ascertain probable behaviour in flight and, last but not least, thorough flight testing are needed.

The Chance Vought F8U Crusader has two pairs of leading edge flaps, set at different angles of incidence, as well as a pair of trailing edge flaps.

2. Structural airframe configuration

2.1 The necessarily low **thickness/chord ratios** (see 1.1 and 1.2) reduce wing strength and aggravate the problem of housing the undercarriage.

SOLUTION : For moderate supersonic Mach numbers the delta-wing configuration offers slightly more favourable spar heights and still just sufficient stowage space for the undercarriage; for higher Mach numbers (and straight-wing configuration) the only solution is to retract the undercarriage into the fuselage. Strength considerations may necessitate use of high-strength steel spars, steel sandwich wing panels or solid wings.

Chance Vought F8U Crusader undercarriage.

2.2 If only the fuselage is available for fuel storage, **fuel capacity** is severely limited by the small fuselage diameter and the small permissible centre of gravity travel (full/empty).

SOLUTION : If longer ranges are required, external tanks (of supersonic configuration) are carried at the wing tips or beneath the fuselage.

Long-range version of the Lockheed F-104 Starfighter.

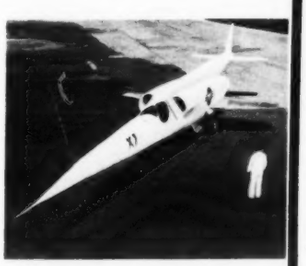
2.3 Exceptionally good **surface smoothness** in all parts exposed to the air flow is needed in order to reduce the skin drag which rises considerably in supersonic flight.

SOLUTION : Use is made of thick (integrally stiffened) skin sheets with high local rigidity, accurately machined to their external shape and highly polished. To limit the number of joints, extra long plates (for wings) or sheets (for less stressed parts) are chosen.

Extra long wing plates for the North American F-100 Super Sabre.

2.4 In supersonic flight fuselage nose, cabin windshield, wing and tail leading edges are subject to increasing aerodynamic **heating** of their surfaces due to air friction. Even in the cold, thin air of the stratosphere, ram temperatures are an average of 0 °C at Mach 1, 150 °C at Mach 2, 380 °C at Mach 3, 700 °C at Mach 4, 4,000 °C at Mach 10.

SOLUTION : Heat-resistant materials, such as titanium, stainless steel and nickel alloys are displacing conventional aluminium alloys; windshields are made of heatproof glass. Ceramic coatings and thicker skins can substantially postpone the time of critical heating (thermal lag). For lengthy flights at high Mach numbers a continuous heat balance through radiation, sweat cooling or circulation cooling will have to be provided.



The twin-jet Douglas X-3, designed for high Mach numbers: circulation cooling of the fuselage nose by means of fuel; flat panes of special glass.

2.5 The aerodynamic heating of the surfaces also affects the **interior of the aircraft** (cabin, fuel tanks etc.) and is aggravated by the heat given off by the power plant, blowers and pumps, generators, transformers and radio tubes.

SOLUTION : The aircraft must be designed as a "thermodynamic whole" (cf. Convair B-58), with all available heat sinks (e. g., fuel and liquid oxygen) being used for cooling. In addition insulation of the fuel tanks and refrigeration of the cabin are essential.

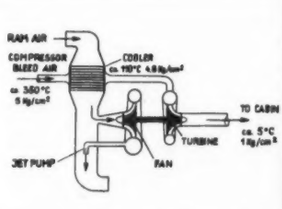
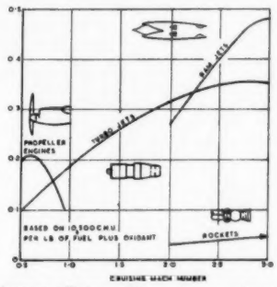


Diagram of a combined pressurization and cold air unit for the cockpit (from E.W.Still, Normalair).

3. Power plant design

3.1 For supersonic flight the designer has the **choice** between (1) turbojets, (2) turbojets with reheat, (3) ramjets, (4) rocket motors, (5) combination power plants—with the limitation that categories 1 to 3 are suitable only for altitudes below 100,000 ft. and for Mach numbers up to M = 4.

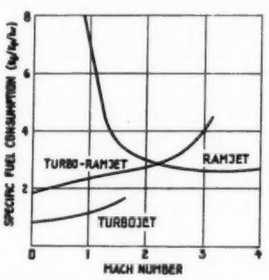
SOLUTION : Bearing in mind the design Mach number, the designer chooses the power plant category which promises the lowest fuel consumption (highest efficiency):
- **— turbojets (without or with reheat) up to approx. Mach 1.5 and Mach 3 respectively;**
- **— ramjets in the Mach 2 to 4 range;**
- **— rocket motors above Mach 4 and as auxiliary engines for ramjets (at low Mach numbers) and turbojets (for short-period power boosting).**



Average efficiency (thermal × mechanical × propulsive) of aircraft engines plotted against cruising Mach number (from R.F.Creasey).

3.2 While rocket motors (propellant consumption 16—18 lbs./lb.t/hr) can provide only very limited range in sustained flight (not for ballistic trajectories), the **fuel requirements** of air-breathing engines in supersonic flight are also very high and restrict range (see diagram).

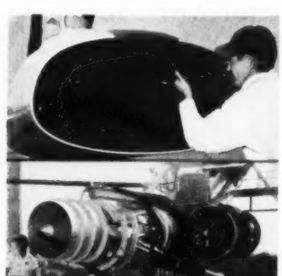
SOLUTION : (1) Efforts are made, through suitable aerodynamic design and provision of high-power turbojets, to manage without reheat for as long as possible (e. g., in supersonic climb); (2) special fuels with particularly high calorific values (e. g., solutions of boron and magnesium in liquids) are used for afterburners and ramjets; (3) temperatures in combustion chambers and turbines are increased (better structural materials).



Fuel consumption of air-breathing engines plotted against Mach number (from J.W.Frozard).

3.3 Performance and consumption of air-breathing engines in supersonic flight depend to a very high degree on the **design of the intakes,** where the air flowing in at supersonic speed passes through a shock wave, is slowed down to subsonic speed, suffers a (highly desirable) increase in pressure and is (undesirably) heated. Shock wave interference in the intake must be avoided, and the section varied, where possible, to suit varying altitudes and speeds.

SOLUTION : Sharp-lipped (pitot) intakes (for Mach 1 to 1.6) creating a straight compression wave or multi-shock intakes with central body (above Mach 1.6) creating two or three oblique shock waves are used. The central bodies can be shifted in the longitudinal direction, so that the shock waves always strike the intake lips and optimum air mass flow can be set approximately at all times.



Pitot intake of the N.A.A. F-100 (top) and multi-shock intake (bottom) of the Convair B-58.

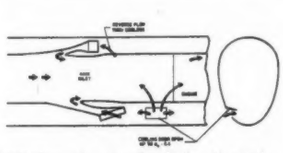
3.4 Performance and consumption are equally dependent on the **design of the exhaust pipe.** Here allowance must be made for operation with and without reheat.

SOLUTION : Convergent-divergent jet pipes are used, and their exit section varied by means of segment or eyelid flaps.

The Chance Vought F8U Crusader's jet pipe (with afterburner ring and segment flaps).

3.5 Adequate **cooling** of the lubricant and the engine accessories must be ensured at all Mach numbers.

SOLUTION : Provision of secondary air circuits (with intercoolers, jet pumps etc.), through which air flows in the opposite direction, if required, during ground runs and at low forward speeds.



Secondary air circuit of the Hustler's engines in "counterflow" operation on the ground.

4. Pilotage

4.1 As altitude increases, the normal ambient atmosphere becomes increasingly **inimical to man.** If the pressurization system fails or the pilot must bail out above 23,000 ft., pure oxygen must be breathed, above 33,000 ft. oxygen under increased counter-pressure (pressure suit). Above 80,000 ft. conventional pressurization working on compressed ambient air no longer suffices.

SOLUTION : Pressure suits are essential for high-altitude flight. The U.S.A.F.'s T-1 pressure suit, for example, has four inflatable rubber tubes distributed over the pilot's back, legs and arms, to ensure—via a system of tapes—even (mechanical) pressure over the whole body. For extreme altitudes a hermetically sealed, air-conditioned cabin is used.

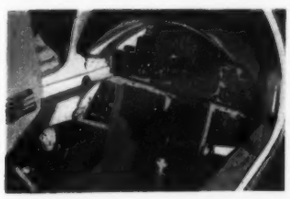
Convair Chief Pilot R. L. Johnson demonstrates the U.S.A.F.'s T-1 pressure suit (with oxygen bottle for bail-outs), which also protects the pilot from the effects of accelerations.

4.2 In supersonic flight at medium altitudes very high **turn accelerations** (up to 7g) can occur. Even moderate accelerations (2 to 3 g) are generally of longer duration, because of the large radius of turn, than in subsonic flight.

SOLUTION : Anti-G suits are worn to prevent the blood from collecting in the lower parts of the body through pneumatic counter-pressure on the abdomen, seat and thighs. The U.S.A.F.'s new T-1 pressure suit also serves as anti-G suit.

4.3 The pilot's **perception and reaction times** cannot be reduced. Thus, as speeds increase, the "blind" distances covered by the aircraft—before the pilot can take control action—grow.

SOLUTION : Automation of pilotage through installation of 3-axis autopilots and stabilizers; simplification of instrument readings.



Autopilot (left) and instrument panel (with target radar screen) in the Lockheed F-104.

4.4 The same problem of "blind" distances also complicates **navigation.**

SOLUTION : Automation of navigation by direct transfer of radio signals to the autopilot and provision of computers (for target approach, instrument landing, indication of residual endurance etc.); increasing use of inertial navigation (accelerometers and integrators).

Diagram of a gyro-stabilized platform for the accelerometers of an inertial navigation system (from N. F. Parker).

4.5 High speeds and altitudes reduce the chances of safe **bail-out** for the crew.

SOLUTION : Up to roughly Mach 1.5 and at altitudes below 50,000 ft., ejection seats with powder cartridges or rockets (RESCU = Rocket Ejection Seat Catapult, Upward) combined with helmeted pressure suits (e.g., the T-1) offer acceptable chances. Ejection may be upwards (beware of fin!) or downwards as in the Lockheed F-104. At higher speeds and altitudes the whole cabin must be separated from the aircraft and stabilized in free fall (Douglas rescue capsule).

Mark 3 powder cartridge ejection seat (left) and Convair RESCU rocket ejection seat (right).

5. Ground organization and training

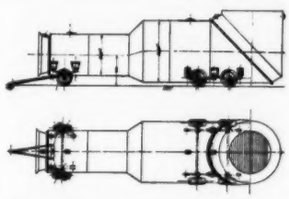
5.1 The very high wing loading of supersonic aircraft and their low max. lift in slow flight will still further increase the **take-off and landing distances** normally required.

SOLUTION : The only solution for supersonic civil aircraft is to build still bigger airports. Military supersonic aircraft could take off vertically or be catapulted; landing can be braked by arrester cables, thrust reversal and brake rockets.

Zero-length launcher for the Republic F-84 subsonic fighter-bomber.

5.2 Afterburners, ramjets and rockets make a tremendous **noise,** which, in the critical sectors (5 o'clock and 7 o'clock position in relation to the direction of flight), can exceed the pain threshold (120 phons) even several hundred yards behind the aircraft.

SOLUTION : Mobile silencers are used for engine test runs in aircraft; take-off and climb near the ground should be possible without use of the afterburner (or ramjet or rocket). Military airfields must be kept away from residential areas.



Mobile three-axis airfield silencer for afterburner engines of up to 17,600 lbs. thrust (weight 14 tons; Dr. Bausch).

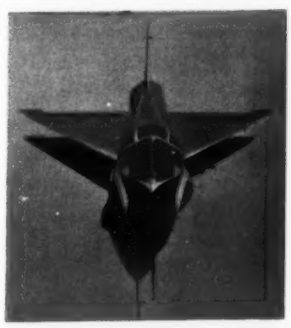
5.3 Bad visibility at high altitudes and very large radius of turn (up to 10 miles at 50,000 ft.) complicate **air defence** against a fast, high-flying enemy.

SOLUTION : The fighter control station on the ground, backed by long-range radar chains and computers, directs the fighter accurately to the enemy (time, position, height, angle) by R/T. The fighter carries automatic target radar and identification equipment.

R.C.A.F. personnel at the radar scopes of a fighter control station.

5.4 Flying a supersonic aircraft makes exceptional demands on the pilot's **mental and physical qualities,** as well as on his familiarity with the aircraft.

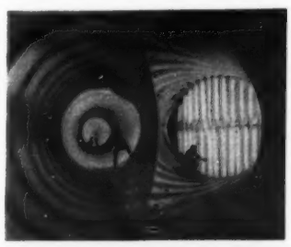
SOLUTION : After passing a thorough medical and psychiatric examination and a rigorous selection at the preliminary flying school, future pilots are trained on flight simulators and two-seat versions to acquaint them with all the features of the combat type.



Convair TF-102A two-seat version.

5.5 Research, development, manufacture and maintenance are becoming increasingly complicated and require **more and more equipment and personnel.**

SOLUTION : Increase in appropriations, expansion of research centres, creation of new training establishments, attraction of engineers and technicians by improving conditions of employment, increase in number of technical officers and N.C.O.'s in combat units and staffs.



The N.A.C.A. Unitary Wind Tunnel, with two supersonic test sections, at Langley Field (cost $ 15,500,000).

Supersonic Vehicle of Commerce... Supersonic Weapon of War

By John W. Crowley, Jr.,
Associate Director for Research,
National Advisory Committee for Aeronautics

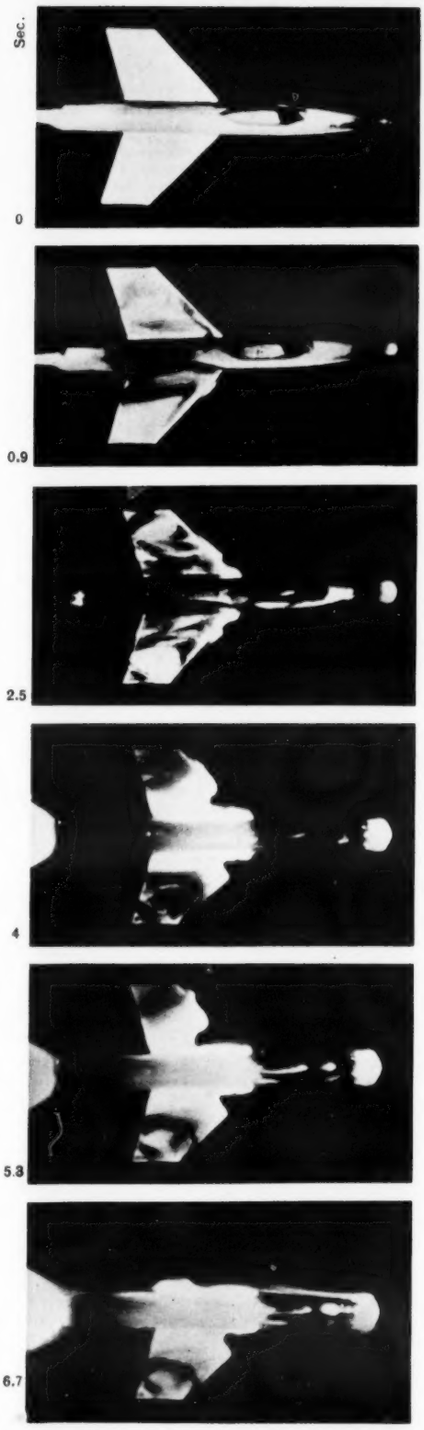
From its inception in 1915, the National Advisory Committee for Aeronautics has had the duty, received from the Congress of the United States, "to supervise and direct the scientific study of the problems of flight, with a view to their practical solution . . ." It is the research which the N.A.C.A. is conducting at its own laboratories to find solutions for "the problems of flight" that I propose to discuss. Space will permit only mention of a second major activity of the N.A.C.A., the coordination of aeronautical research in the United States.

Today, the N.A.C.A. is focusing most of its research effort upon acquisition of the information necessary for early achievement of three goals:—

1. Exploitation of the great potential of the airplane as a supersonic vehicle of commerce and a supersonic weapon of war. Nine years have passed since the first flight at a speed faster than that of sound, but there remain difficult problems in the supersonic flight range.
2. Construction of airplanes speedy enough to bring any two points on the globe within a comfortable day's journey. Peter Masefield has noted that the human frame is incapable of sitting comfortably for more than, say, four hours at a time.
3. Development of ballistic missiles that can be guided accurately across intercontinental distances to their targets without being destroyed by aerodynamic heating.

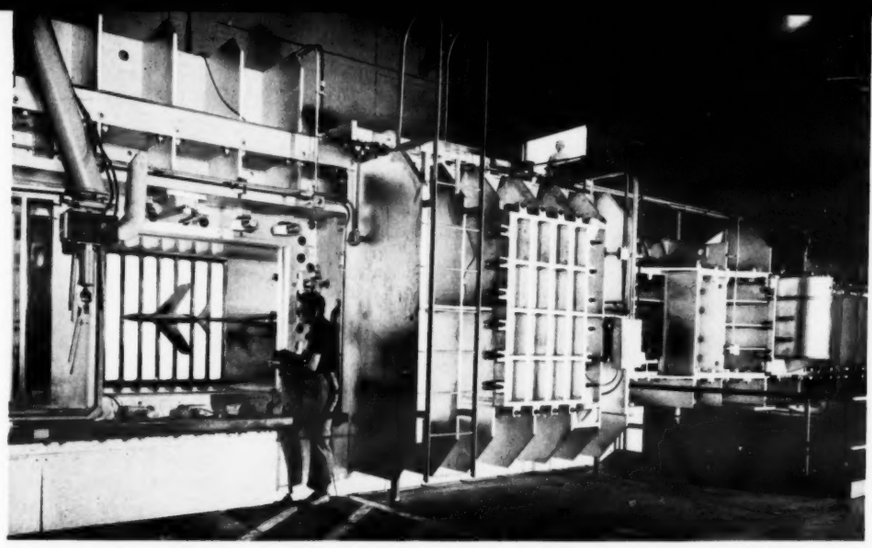
With respect to the first of these three goals, stability and control are among the most vexing problems. Ironically, these are the same problems considered in the first Report published by the N.A.C.A. in 1915. The extension in four decades of speed by tactical airplanes from less than 100 m. p. h. to more than 1,000 m. p. h. has served only to increase their complexity and the severity of the problems involved.

In this area, to cite a single example, a most serious problem faced by the designer is the decrease in directional stability of supersonic fighters that occurs as speed increases. Conventional lifting surfaces such as the vertical tail



N.A.C.A. experiments with a steel aircraft model in a rocket exhaust jet. This test simulates the aerodynamic heating of an aircraft flying at around 4,500 m.p.h. at an altitude of 50,000 ft. A small stainless steel model, 2.5 inches in span, melts within 6.7 seconds when placed in the rocket exhaust (8% oxygen, 35% nitrogen, 57% steam; velocity about 7,000 ft./sec.). Nose and wing edges begin to glow after 0.9 secs, the nose grows blunter and the wings begin to melt, and finally the whole fuselage glows and the wings disintegrate. Critical times would, of course, be longer for larger models.

Model of a supersonic aircraft in the subsonic wind tunnel at Langley Aeronautical Laboratory. As good flying qualities are needed not only in high-speed flight, but also during take-off and landing, aerodynamic testing must also cover the model's stability qualities at low speeds.



Scale model of the Bell X-2 research aircraft in the Unitary Plan supersonic wind tunnel at Langley Aeronautical Laboratory. Mach number range 1.5 to 5.

tend to lose their effectiveness as the Mach number increases. Large supersonic wind tunnels are invaluable in studying in detail the advent and seriousness of the problem as it affects a particular design, and also the effectiveness of remedial design modifications.

Reaching the second goal—the very high-speed commercial aircraft—may be accomplished in a winged vehicle that would travel at 3,000 m. p. h. or more at very high altitudes. Already a tentative name has been suggested to describe this projected man-carrying craft—the hypersonic glider. It would be rocket powered, but, particularly at the lower end of the speed scale, it would depend to a large extent on aerodynamic lift rather than the inertia of launching to support it in flight. The operational altitude doubtless would be a compromise between the optimum for lift sustenance with the least possible drag, and that for minimum aerodynamic heating.

Whereas aerodynamic heating is but one problem among many when one seeks to bring the hypersonic glider to reality (the N.A.C.A. has been working for several years on such matters as pilot control in flight and landing, rocket motor improvement, and aerodynamic and structural considerations), it is perhaps the paramount problem with respect to the intercontinental ballistic missile. At the altitudes and speeds contemplated, air temperatures measured in thousands of degrees will be generated. The fundamental processes that occur in air under such conditions must become clearly understood because they affect the manner in which heat is transferred to the missile from the disturbed atmosphere through which it is travelling.

Designing equipment that will be useful in conducting the necessary fundamental research has been formidable. The great difficulty has been in learning how to duplicate in the laboratory the extremely high temperatures and other conditions of future flight. Only recently have ways been found to build small pilot models with which to demonstrate the practicability of constructing the radical new tools that can be used in extending the limits of our knowledge.

One approach has been to build apparatus in which aerodynamic heating can be generated to match very high Mach number conditions. Such equipment includes shock tubes, special compressors, and light-gas guns. In the shock tube, for example, a shock wave heated to many thousands of degrees Fahrenheit passes over a model, but the desired condition can be maintained for only a time measured in microseconds.

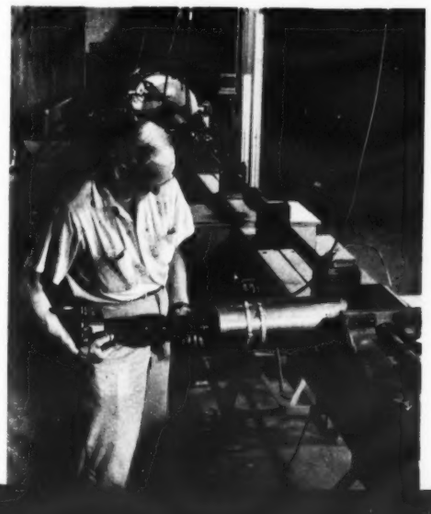
A special helium gun, constructed at the N.A.C.A.'s Ames Aeronautical Laboratory, is capable of firing a small model at speeds up to Mach 20. In one experiment a magnesium model was fired at a velocity of 11,000 m. p. h., and although the time of flight was extremely short, the heat input was high enough to ignite the model. Much can be learned from this technique because, despite the difficulty of obtaining information from the rapidly moving model, the temperature simulation is close to that experienced in flight.

Combustion-products tunnels are proving useful in studying the heat problem at the lower end of the hypersonic range. These tunnels, used at the N.A.C.A.'s Langley Aeronautical Laboratory, are essentially ram-jet or rocket engines exhausting their hot jets through supersonic nozzles. Although the chemical composition of the exhaust gases differs from that of air, these jets are valuable because they can be used to duplicate the temperatures, velocities, and pressures of air streams at speeds up to M-8 or higher.

Another technique, proved only recently at the Langley Laboratory in a small, pilot model, provides a jet of air heated to 4,000 °F corresponding to that encountered above Mach 5. The apparatus uses a heat exchanger lined and charged with ceramic materials. It has proved so successful that a larger version, with greater capacity, is now being constructed.

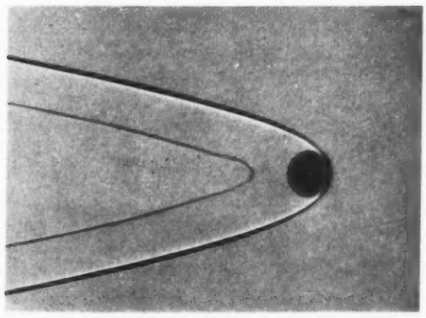
In a time when the Air Force and the Navy are taking delivery of fighters capable of operation at speeds above 1,000 m. p. h., there is urgent need for information about how to cope with a temperature rise, due to aerodynamic heating, of as much as 300 °F. Keeping the pilot, the complex electronic gear, the weapons system, and the fuel cool under such conditions

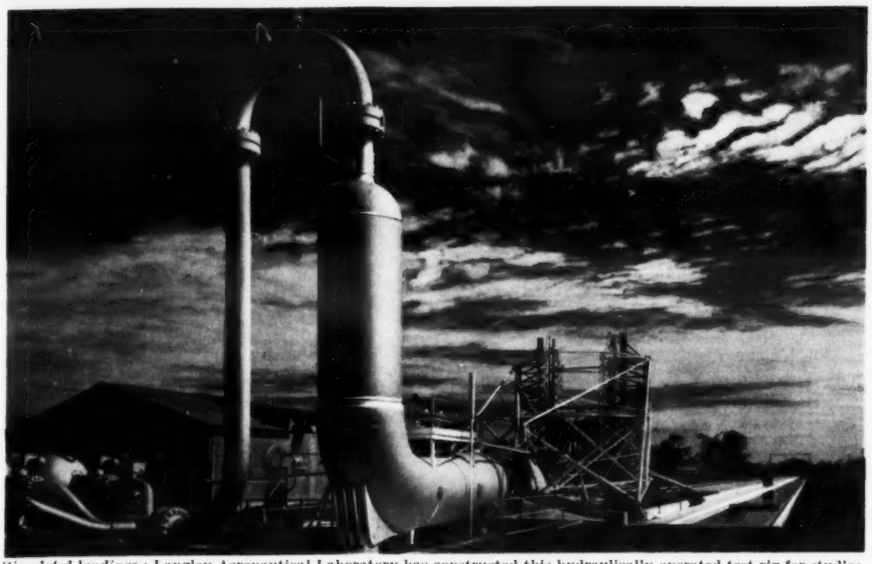
Hypersonic tests: closing the breech mechanism of the light-gas gun at Ames Aeronautical Laboratory which gives small missile models a speed of up to Mach 20.



A model leaving the light-gas gun at 10,000 m.p.h. It generates sufficient light to take its own photograph, for which an exposure of minute fractions of a second suffices.

A sphere travelling at 10,000 m.p.h. and its shock wave (shadowgraph picture taken at $^1/_{10}$ microsecond).





Simulated landings : Langley Aeronautical Laboratory has constructed this hydraulically operated test rig for studies of ground loads on aircraft during landing. It consists of a weighted carriage (centre) which is catapulted by a water jet (from the L-shaped pipe) along the 2,200 ft. track, reaching speeds of around 150 m.p.h. At the end of the track the carriage is caught by aircraft carrier arrester cables; the water basin (far right) is used for hydrodynamic tests on flying boat models, etc.

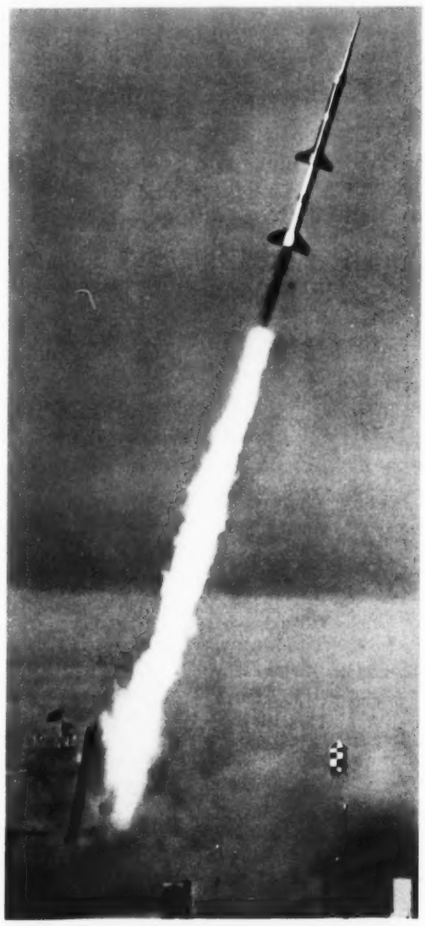
Detail of the hydraulic test equipment: this aircraft wheel and sprung leg (for a landing weight of roughly 50 tons) is loaded to 20,000 lbs. and is catapulted 400 ft. in 3.5 seconds. The wheel runs on a concrete track.

is difficult enough; fully as serious is the parallel problem of maintaining the structural soundness of the airplane.

In studying aerodynamic heating in the Mach range below 5, increased use is being made of flight vehicles. These include research airplanes and small, rocket-propelled, specially instrumented models. Among the specially designed airplanes now being flown at the N.A.C.A.'s High-Speed Flight Station at Edwards, California, are the Bell X-1B and X-1E. The first of these has been fitted with temperature-recording instrumentation to permit detailed evaluation of aerodynamic heating on an airplane flying above Mach 2. The X-1E is fitted with a 4-percent-thick wing and also with additional tankage to permit plus Mach 2 flight for a somewhat longer time. The recent loss of the Bell X-2 in the tragic accident which cost the life of an Air Force pilot will inevitably slow the rate of full-scale flight research on the heating problem. Now under construction by North American Aviation is the X-15, designed to fly faster and higher than man has ever ventured. The new airplane is being procured by the Air Force as a part of the continuing flight research effort in which the military services, the aircraft industry, and the N.A.C.A. are teamed.

The rocket-propelled models—also useful in study of aerodynamic heating at hypersonic speeds—are fired from the N.A.C.A.'s Wallops Island, Virginia, field station. The models are instrumented with thermocouples so positioned as to enable measurement of the desired heat-transfer data. This information, together with recordings by pressure instruments and accelerometers, is telemetered in flight by a tiny radio transmitter in the model to a ground receiving station.

In its studies of heating problems at hypersonic speeds, N.A.C.A. accelerates small models with the aid of four-stage rockets. Top speeds of up to Mach 10.4 were obtained during these tests at Wallops Island.



As many as four stages of rockets propel the research models to the desired altitude and speed. Solid propellant, "off-the-shelf" rockets are used to keep the expense of firings at a minimum. The highest announced speed reached by one of these four-stage rocket-propelled research models is Mach 10.4. Because aerodynamic heating becomes most serious in the denser air near the earth, use of an "over-the-top" trajectory is being made. Models fired in this manner are propelled by four rocket stages. The first two stages are shot off while the model is climbing, while firing of the two remaining rockets is delayed until after the model has begun to descend. In this manner, information about heating rates at the very high speeds encountered during the re-entry period of a missile's journey may be obtained.

Space does not permit consideration of the large effort being focused on power plant problems at the N.A.C.A.'s Flight Propulsion Laboratory, nor on the increasing attention being given to structural problems at the Langley Laboratory. Nor is there time to discuss N.A.C.A. research on such problems as turbulence, gusts and landing loads, or those peculiar to the seaplane and the helicopter.

It may be enough to say, there is much to be done and the gains from the doing will continue to be very great.

The Surface-to-Surface Missile, Today and Yesterday
(II)

By Frederick I. Ordway, III, Executive Vice-President,
General Astronautics Corp., Oyster Bay, New York.

The author holds an S. B. degree from Harvard University where he studied the geo-sciences, petroleum and mining engineering and geology, chemistry, astronomy and mathematics. He formerly was an engineer with Reaction Motors Inc. and the Guided Missiles Division of Republic Aviation Corp. and is a member of a considerable number of rocketry and astronautical societies, in the U.S.A. and abroad.

In the first part of his article (cf. Interavia, Review of World Aviation, *No. 12, December 1956) the author sketched the development of rockets and missiles through the centuries to the end of World War II and drew a brief outline of guidance and control methods. In this January instalment he writes about American surface-to-surface missiles and the controversy which is going on behind the scenes at the Pentagon Building in Washington about which Service should exercise control over U.S. guided missiles in general.* — *Ed.* —

U. S. Surface-to-Surface Missiles

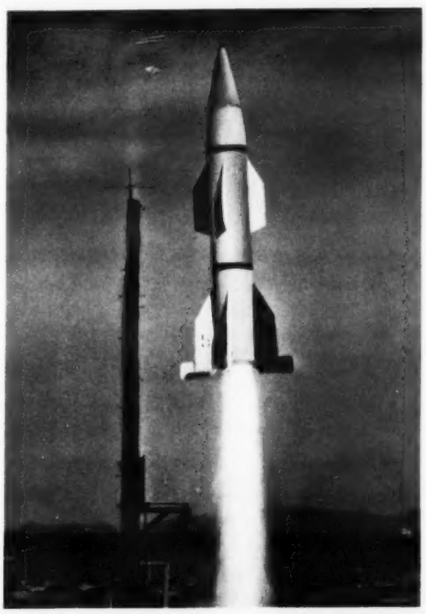
World War II surface-to-surface rocketry in the United States was fairly well limited to beach barrage missiles that preceded American troops ashore on many a Pacific Island, and short range Bazooka-type weapons. Of the barrage rockets, the 3.5 inch "Old Faithful," and the 3.5 and 5.0 inch spin-stabilized rockets were perhaps the best known. A number of adaptable heads could be used depending on the purpose, i.e., general purpose, armor-piercing, high capacity, chemical warfare, smoke or pyrotechnic.

Following the war, a wide rocket development program was initiated which in the surface-to-surface field has today resulted in a fair number of production articles. For convenience, Table 1 divides SSM's development into eleven areas, while Table 2 gives the status of key U.S. missiles and missile programs of interest today.

Ballistic Missiles

The most spectacular missiles, still in the research and development stage, are of course the large ballistic missile programs, both I.R.B.M. and I.C.B.M. *Atlas* is the oldest, having its roots directly in the 1946–47 Convair *MX-774* project[1]. The Air Force and its producer expect big things of it, and its large thrust motors (it has three chambers) have been repeatedly tested at North America's Santa Susana rocket engine test facilities. A big $41-million Convair-Astronautics plant is being built to produce *Atlas* near San Diego, which is expected to employ between 6,000 and 7,000 persons. Support facilities have been promised by American Machine and Foundry Co.

[1] Probably the first serious U. S. ballistic missile work was associated with the Convair *MX*-774 project. Three missiles, fired for upper air research, were powered by Reaction Motors Inc.'s four-chamber rocket engines. The project was cancelled, but later Convair picked up a new MX study contract. Once the relatively light weight, reduced size, nuclear bombs were available (by 1953), an A. F. Strategic Missiles Evaluation Committee was set up, and intensive I.R.B.M.–I.C.B.M. projects began to take shape.



One of the early U. S. surface-to-surface missiles was the General Electric *Hermes* A-1 which had a range of 30 miles. Length, 25 ft. 6 in.; diameter, 2 ft. 10 in.

One of the great problems associated with ballistic missiles is the development of suitable nose-cones, which house control equipment and warhead, and which must face conditions similar to those of meteors. G. F. Metcalf, manager of General Electric's Special Defense Projects Department, refers to the task as of "tremendous magnitude," adding that the "frontiers of science in physics, chemistry, metallurgy, electronics and other basic sciences must be expanded and new research tools must be developed to enable scientists to work in technical areas never before explored".

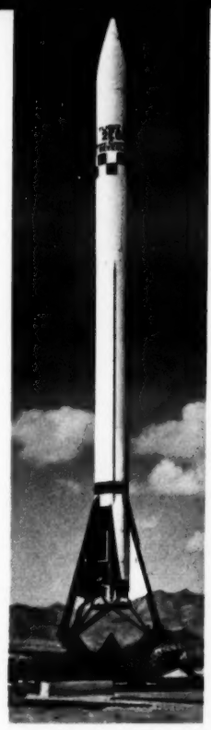
The *Jupiter* missile program grew directly out of the *Redstone* short range ballistic missile developed by the Army Ballistic Missile Agency

One of the U. S. Army's operational tactical weapons is the Douglas *Honest John* unguided artillery rocket. Range, about 20 miles.

under Dr. Wernher von Braun's technical direction. While a fair number of pre-production *Redstone* models were built at Redstone Arsenal, the Chrysler Corporation has already been given a $3,175,000 contract for engineering and manufacturing of the *Jupiter* vehicles (today, the old Redstone is known as *Jupiter A*, and the multistage I.R.B.M. is *Jupiter C*), and expects at least another $15,000,000 in the immediate future. Advanced as this I.R.B.M. program is, however, the Department of Defense has given priority to the competitive Air Force *Thor* missile. *Jupiter C* enjoys a nebulous backup status, but is undoubtedly much farther along than *Thor*.

Redstone is a tactical extension of the V-2 and can carry a nuclear warhead. It is in service with the 217th Field Artillery Battalion, and is being produced at the rate of one a month, a figure that will presumably be increased. It is transportable by land, sea or air, and has the further mobility feature that all support equiment can be transported by existing aircraft.

Titan, a two-stage missile, will be developed and built at a new $20,000,000 plant on a 4,000 acre site at Denver, Colorado. North American and Aerojet-General will handle the power plant development, with Reaction Motors, Inc., providing combustion chambers under Aerojet sub-contract.



Also operational with the U.S. Army is the Firestone *Corporal*, which has a range of about 125 miles.

Longest-ranging U. S. Army rocket is the 300-mile-range *Redstone*, from which the *Jupiter* I.R.B.M. is being developed for (now) the U.S. Navy, possibly also the U.S.A.F.

Few details are available on *Thor*, save that it will be produced at Santa Monica and that the first test firings are expected before the end of 1957. Unlike *Jupiter C*, it is a one-stage configuration.

As General G. A. Schriever, head of the Western Development Division, Air Research & Development Command, has pointed out, no new basic knowledge is needed to come up with a workable I.C.B.M., the tasks remaining being simply tied in with a rather imposing "systems engineering job." With the advent of relatively small atomic and hydrogen warhead packages, the overall I.C.B.M. program changed from one of semi-speculation to one of definite technical feasibility. The fact that Congress has recently voted the Air Force an additional $100,000,000 to be largely used on ballistic missile research and development and that the Army has received $25,000,000 for I.R.B.M. facilities, indicates the rapidly increasing importance of ballistic missiles in the eyes of defense planners. And, as noted by Lt. General Thomas S. Power, Commander of the Air Research & Development Command, last April, the Air Force is getting all it can out of the dollar by ensuring that many of the major components and subsystems for the *Thor* I.R.B.M. and the *Atlas* and *Titan* I.C.B.M.s be identical. It is hoped that by conducting three roughly parallel large missile programs using many identical parts, the development period

Table 1

1. Small ordnance rockets
2. Close support missiles
3. Heavy rocket artillery, unguided
4. Short range, guided, tactical ballistic missiles
5. Intermediate range ballistic missiles (IRBM)
6. Intercontinental ballistic missiles (ICBM)
7. Cruise type, jet propelled short and medium range bombardment missiles
8. Cruise type, jet propelled long range and intercontinental bombardment missiles
9. Surface-to-underwater missiles
10. Underwater-to-surface missiles
11. Underwater-to-underwater missiles

Table 2 Leading U.S. SSM's

Name	Type	Status	Service
Atlas	Ballistic (ICBM)	R + D	Air Force
Corporal	Ballistic	Operational	Army
Honest John	Ballistic	Operational	Army
Jupiter	Ballistic (IRBM)	R + D	Army – Navy
Matador	Air Breather	Operational	Air Force
Navaho	Air Breather	R + D	Air Force
Redstone	Ballistic	Operational	Army
Regulus	Air Breather	Operational	Navy
Snark	Air Breather	R + D	Air Force
Thor	Ballistic (IRBM)	R + D	Air Force
Titan	Ballistic (ICBM)	R + D	Air Force

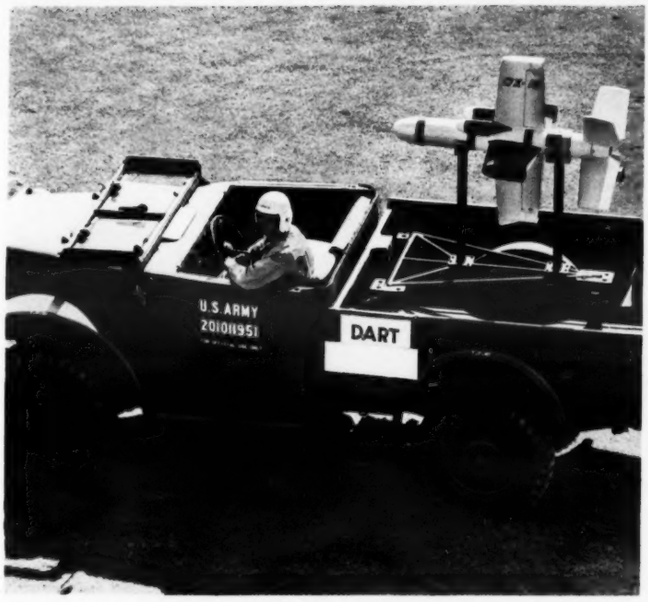
Table 3
IRBM, ICBM Air Force Projects

Function	Company Assigned
Airframe:	1. Douglas Aircraft Co. (*Thor*, IRBM) 2. General Dynamics Corp., Convair Division (*Atlas*, ICBM) 3. Glenn L. Martin Co. (*Titan*, ICBM)
Guidance:	1. American Bosch Arma Corp. 2. Burroughs Corp. 3. General Electric Co., Heavy Military Electronics Division 4. General Motors Corp., AC Spark Plug Division 5. Massachusetts Institute of Technology 6. Sperry-Rand Corp. 7. Western Electric Co.
Nose Cone:	1. Avco Manufacturing Corp. 2. General Electric Co., Special Defense Projects Dept. 3. Lockheed Aircraft Corp., Missile Systems Division
Propulsion:	1. Aerojet-General Corp. 2. North American Aviation, Rocketdyne Division
Miscellaneous:	Air Products also has a contract in these developments

Table 4 U.S. I.R.B.M.'s and I.C.B.M.'s

	Military Designation	Prime Contractor	Cognizant Agency	Power plant Manufacture	Guidance	Range miles	Altitude miles	Power plant thrust lb.	Firing time minutes	Cost (estimated) $	Velocity Mach No.
ICBM											
Atlas	SM-65 (WS-107A)	General Dynamics[2] Corp. (Convair)	U.S. Air Force	North American Aviation	G. E. + Arma	5,000	500–800	1/135,000 2/100,000	8—12 (sustainer; 3)	$1,500,000 for test vehicle, captive run $4—5,000,000 full missile	15
Titan	WS-107	Glenn L. Martin Co.	U.S. Air Force	North American Aviation, Aerojet-General	—	5,000	—	—	—	—	15
IRBM[1]											
Jupiter	—	Army Ballistic Missile Agency Chrysler Corp.	U.S. Army – U.S. Navy	North American Aviation	Ford Instrument Co.	1,500	—	120—150,000 (?)	—	—	15
Thor	WS-135A	Douglas Aircraft Co.	U.S. Air Force	North American Aviation	A. C. Spark Plug Division, General Motors Corp.	1,500	—	—	—	—	—

[1] A Navy solid propellant IRBM development program has been rumored. [2] Systems Management: Ramo-Wooldridge Corp.



Newcomer to U. S. Army arsenal is the *Dart* cable-guided anti-tank missile developed by Aerophysics Development Corporation, Pacific Palisades, Cal. It is about five feet long.

The U. S. Air Force's operational tactical missile is the Martin *Matador* TM-61A pilotless bomber powered by an Allison J-33 jet. Range is up to 620 miles.

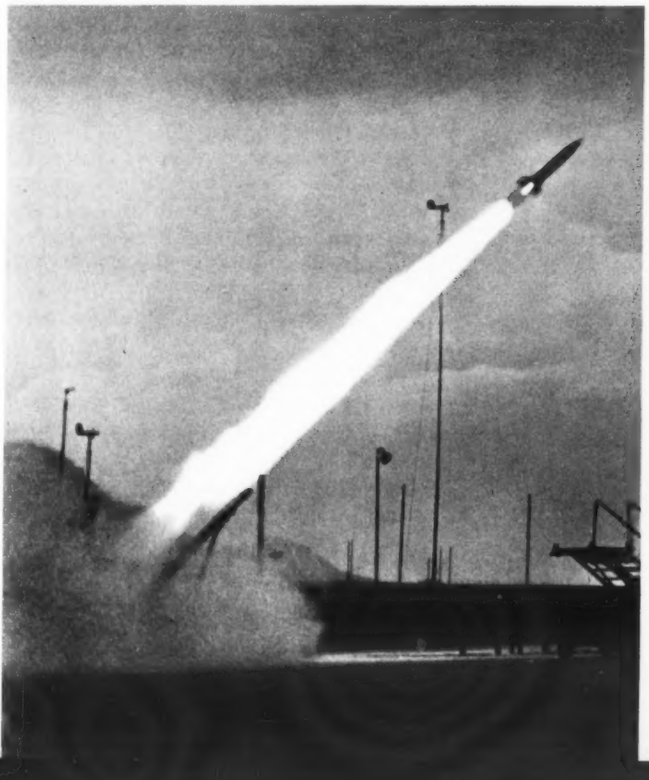
will be greatly shortened and the cost will be substantially lowered.

The Air Force I.R.B.M. and I.C.B.M. development programs fall under the jurisdiction of the Western Development Command. Both the Ballistic Missiles Office of Air Materiel Command and the Ramo-Wooldridge Corporation are closely tied in with W.D.C.'s activities on the advisory and managerial basis. W.D.C.'s decisions on ballistic missile matters are final except as amended by either the Air Force Ballistic Missile Committee (under the Secretary, U.S.A.F.) or "missile czar" E. V. Murphree's Missile Advisory Committee (Office, Secretary of Defense). W.D.C. has handed out the ballistic missile systems assignments as shown in Table 3.

Who shall use guided and unguided surface-to-surface missiles? This question had been at the bottom of an inter-Service dispute between the Army and the Air Force—in which the Navy later also joined—for well over a year. The Air Force claimed that it was responsible for both air defense (which means surface-to-air missiles) and for the bombardment of enemy targets, especially distant ones (which means I.R.B.M.'s and I.C.B.M.'s). The Navy wants I.R.B.M.'s for its missile-submarine and missile-cruiser combinations as an offensive weapons system.

The matter was partially settled on November 27th, 1956, by Defense Secretary Charles E. Wilson who in an eight-page memorandum decreed that the Army shall be responsible for (a) "point-defense" anti-aircraft missiles and (b) for missiles used for close support, i.e. SSM's with a range of up to 200 miles which, however, will not be fired more than 100 miles beyond the front lines. The Air Force, on the other hand, is given responsibility for intermediate-range and long-range ballistic missiles. (To be continued)

Another Army tactical weapon is the 318-mm-cal. Douglas *Little John* field artillery free rocket which has a length of about 12 feet.



The Northrop *Snark* SM-62 of the U. S. Air Force is an air-breathing (Allison J-71 jet) long-range cruise missile. At present development stage its range is about 2,000 miles.

Baling out at High Flying Speeds

By J. Martin, O. B. E., F. R. Ae. S., Managing Director, Martin-Baker Aircraft Co., Limited, Higher Denham, Middlesex.

One is frequently asked what provision is to be made for safe escape from high speed aircraft of the future—flying at supersonic speeds.

In discussion of this subject, people are impressed with high Mach numbers, but I must make it clear that in escape from aircraft it is equivalent air speed, not the Mach number, which is significant. The vital matter is height as this involves the question of the density of the air which is the crux of the whole business. The damaging effect on the human body is due to the ram effect of the high speed air. The impact of this high speed air on the body will be greatest where the density of the air is greatest—namely at sea level. Air at 14.7 lbs. per square inch hurled on the body at 600 m. p. h. would have a far greater damaging effect than air at 2 lbs. per square inch hurled on the same body at the same speed.

For instance, on the 3rd August 1955, Flying Officer Hedley Molland ejected himself from a *Hunter* at a Mach number of 1.1. However, although he stated that the Mach number was 1.1, the indicated speed was only approximately 550 m. p. h. (Molland had superficial injuries due to the installation arrangements of the seat in that particular aircraft.)

In the case of the American pilot, Smith, who shot himself out at supersonic speed at an altitude of 7,000 ft., here of course indicated air speed was much higher and the blast was much greater because of the lower altitude, with the result that this pilot had a very severe time, but he eventually recovered. I would also mention that no stabilizing device was fitted to Smith's seat, and this made matters worse, for the following reason:—

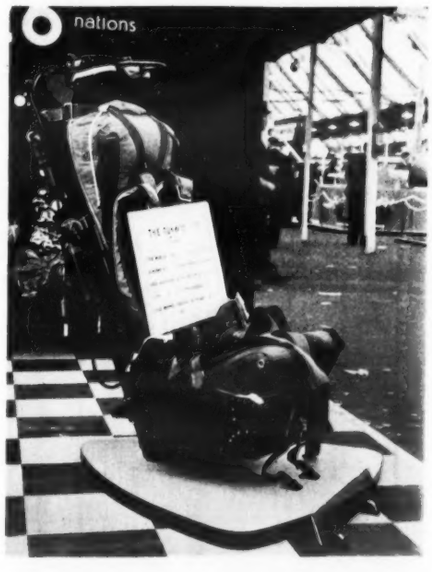
It is shown from tests that the human body is able to withstand, without serious injury, high blast pressures providing they are sustained for relatively short periods—say—of the order of 1/10 second. The performance of our latest ejection seat is such that on leaving the protective envelope of the aeroplane, at high ejection speeds, the seat is brought on to its back by the controller drogue and in this attitude, the blast pressure is not normal to the body axis, but is flowing over it in a brushing manner. This transition from near vertical to horizontal occupies a very short period and the new attitude of the seat has a shielding effect on the occupant. I consider that this, together with effective harness to prevent limbs flailing will enable ejections to be done safely at sea level at very much higher speeds than at present and certainly above Mach 1.

I think it would be fair to say that if it is possible to deal with the case of an aeroplane diving vertically at a low altitude at say even 600 m. p. h. this will cover a great many cases, probably 95% of all attempted escapes.

A pilot not in proper control of the aircraft will tend to reduce speed. Again, the speed will drop if an aeroplane is breaking up, due to the rapid drag rise. As a matter of instinct, the pilot will tend to remain with the aircraft as long as possible.

In any discussion of escape from supersonic aircraft, people are inclined to look to the capsule or pod as a panacea; in fact, I feel there is no problem whatsoever in a high altitude case. There is only the question of survival due to oxygen breathing and so forth. So the enclosed seat or pod will have advantages at say 60,000 or 80,000 ft. but, whilst not wishing to detract from the value of the capsule or pod, particularly for the extremely high altitude escape, I see so many serious disadvantages and penalties that I am inclined to look to the development of the ejection seat as providing a very much better overall means of escape from high performance aircraft at present and in the immediate future. I refer particularly to the inability of pods to provide safe escapes down to ground level. In addition, the engineering problems in marrying the capsule or pod into the conventional type of aircraft are great.

Martin-Baker's latest fully automatic light-weight ejection seat at the S.B.A.C. Exhibition, Farnborough.



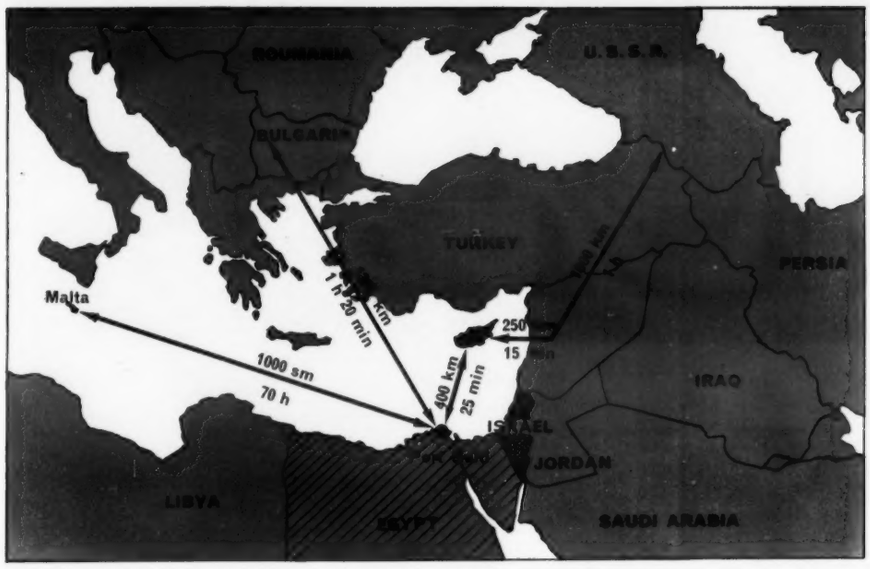
An analysis of escapes from high speed aircraft and of all the fatalities shows that the majority of ejections is made at moderate speeds and that most fatalities occur near the ground at low forward speeds. One must consider the very high speed case close to the ground at a fairly steep diving angle. For this type of escape the ejection seat would appear to have very obvious advantages. Parachute harness and parachutes will have to be improved from a strength point of view to be able to cope with parachute loads of the order of 20 or 25G with a good reserve margin on top of that. Deceleration will have to be applied to the occupant longitudinally, in which manner it is more tolerable. A moment's thought will disclose the fact that the pilot has got to be subjected to very high G loads indeed on his parachute; or if he has a pod, the same applies because the pod must obviously be slowed up at the high deceleration rate. In my opinion, pilots can stand 24 G in an ejection seat without injury if the seat is of proper shape and the rate of rise of G is correct.

Whilst the pundits are busy talking about escape from supersonic aircraft, I have been very much more concerned about developing my seat to enable it to save life in aircraft in use now and in the near future, where the particular problems are those of escape nearer the ground, both at high and low ejection speeds, speeding up the separation of the occupant from the seat after ejection and getting the parachute developed much more quickly. In this connection, we have quite recently done a successful ejection test at 600 m. p. h. with the timing for the release of the parachute set at 1½ seconds. The G forces applied to the pilot's harness were something in the order of 24 G. We followed this up a few weeks ago by carrying out a successful test with the seat stationary upon the ground.

Egypt 1956: A "Textbook" War

British and French spend four days winning an air supremacy they already hold.

By General ***



The main events of the Suez crisis from the geographical viewpoint. The roughly 1,000 nautical mile distance from Malta to Port Said can be covered by landing craft in an average of 70 hours. The Franco-British invasion fleet, which was originally to have been three days at sea, arrived 24 hours late in Port Said. – The flying times indicated between Bulgaria and Port Said, U. S. S. R. and Cyprus, and Cyprus and Port Said are based on a combat aircraft with 600 m.p.h. performance. Thus if the Egyptian Air Force had ventured on a raid on Cyprus, its aircraft would have been over the British airfields within 25 minutes. If the Soviet Union had intervened, Red Air Force bombers could have covered the distance from the Russian border to Syria or Cyprus in roughly one hour and from Bulgaria to Port Said in 1 hr 20 mins.

The Anglo-French campaign in Egypt ended like a staff college exercise suddenly confronted with reality. Its whole conception and realization was based on old-accepted theories, but experience showed that the old recipes were valid only if applied with a little imagination. The military preparations had been worked out with care and the operation was conducted according to the classic rules of official military teaching, but the whole affair was carried through without regard to its framework of reality.

The democracies should have long known that a show of force is possible only if it forestalls the reaction of the opposing system. Secrecy in preparation, surprise in its launching and speed in execution, these are the prerequisites of success. None of these conditions was met in Egypt.

The British and French gambled on the relative immobility of the "Big Two", with each neutralizing the other. Cairo put its faith rather in blackmail through the threat of armed intervention than in intervention itself. In the event of attack, the Egyptians speculated on the reactions of the Arab world and above all on those of the U.S.S.R. If the first of the two Egyptian hypotheses proved false, the second was revealed to be fully justified at the very moment when the attackers were on the point of achieving their objectives.

Israel alone rapidly exceeded the military objectives she had set herself. Originally, Tel Aviv states, the object was to destroy the camp at Nekhl, 75 miles from the Israeli-Egyptian frontier, where the "fedayeen" were trained and from which the Arab "commandos" made their sorties against Israel. The attack began on October 29th, and by the next day General Moshe Dayan's vanguard was within 30 miles of the Canal. On October 31st, after taking Raja, surrounding El Arish, capturing dozens of T. 34 tanks and crossing the whole of Sinai, the Israeli forces were stopped 10 miles from the Canal by the Eden-Mollet ultimatum. In three days, Sinai had been occupied, three Egyptian divisions had been thrown back in disorder, seven thousand prisoners and enormous war booty had fallen into Israeli hands.

Tel Aviv admits that the Anglo-French air intervention facilitated the Israeli task by destroying part of the Egyptian Air Force. But we should not forget that, at any rate officially, British and French aircraft did not go into action until Thursday, November 1st. During the days of Tuesday, October 30th, and Wednesday, October 31st, the Egyptian Air Force could have supported the Arab ground forces and attacked General Moshe Dayan's columns. But its composition was hardly such as to enable it to perform the kind of missions necessary to counter the advance of a land invader. The MiG-15s had to be more or less reserved for interception, and the Il-28s for bombing, since the Egyptian personnel was not highly trained in "strafing" or in attacking convoys. In the face of the *Mystère IVs*, it was unwise to launch the Il-28s into an attack on Israel and hardly rewarding to bomb the Israeli forces scattered throughout the Sinai peninsula. And with the Anglo-French bombing and strafing from November 1st onwards, Colonel Nasser's Air Force had suffered sufficiently heavy losses to enable the Isreali forces, thus relieved of pressure from the air, to encircle and destroy the Egyptian units deployed along the coast from Gaza to the Nile, and to throw back Westwards what remained of the Arab divisions in Sinai. Israeli aircraft, used on ground attack missions, had a decisive effect, as witness, for example, the machine gunning of two Egyptian motorized formations on the road from Ismailia to Nitsana, a repetition of the Guadalajara affair during the Spanish War.

General Moshe Dayan, Commander-in-Chief of the Israeli forces, at a press conference on the successful operations in Sinai.

Not only was Colonel Nasser's air arm badly equipped to support a land campaign, it was in no better position to cope with the first phase of Anglo-Franco-Egyptian hostilities. The MiG-15s had neither the speed nor the range to attack the enemy on its bases in Cyprus. At night the Russian fighters could not hope to be successful against the *Valiants* and *Canberras* in their brief penetrations into Egyptian territory (some 50 or 60 miles at the most). The Egyptian Air Force's few *Meteor NF 13s*, involved in night operations without any real organization for the ground control of interception, were in a scarcely better position. As for the Ilyushin Il-28s, in order to bomb the Cypriot bases, where British and French aircraft were stationed almost wing-to-wing, they

Field Marshal Sir Gerald Templer, Chief of the Imperial General Staff, was in overall charge of the preparation of the Suez operation.

would have had to brave the *Hunters, Mystère IVs* and F-84Fs. These aircraft are superior in performance and had the further advantage of being guided by excellent radar and by a night fighter organization with several years of training behind it, since *Meteor NF 11s* have long been mounting guard over Cyprus. It would therefore have required a great deal of daring and the acceptance of heavy losses to launch the Il-28s on the only operations that could have hampered the British and French, namely attacks on the Cyprus bases.

If, as has been stated, Egypt acquired her air arm at the cost of important economic concessions, the sacrifice has proved to be out of all proportion to the results achieved. In the form in which it was organized and equipped, the Egyptian Air Force simply could not perform the missions that were to be demanded of it and for which it is logical to suppose it was created. The *Mystère IVs* with which the Israeli Air Force had been re-equipped neutralized Egypt's MiG-15s and Il-28s, and it is reasonable to suppose that the Egyptian crews were nonplussed in the face if not of the quantity at any rate of the quality of the equipment opposing them. It is one of the characteristic features of the air arm that the security it offers can be annulled overnight. In less than a month the deployment of superior equipment reversed the balance of forces and destroyed the aerial supremacy which Egypt had previously held in the Eastern Mediterranean.

A providential week

Within a few days of the nationalization of the Canal, French and British admirals, snorting with impatience, told the press that their fleets were ready and awaited only an order from their governments. Then the voice of the politicians sounded above that of the military, and the use of force was officially banned.

But, while the British and French staffs were carefully preparing their plans for military intervention, without knowing whether they would ever be put into effect, the international scene was changing rapidly. The events in Poland and then in Hungary set the U.S.S.R. before serious political and military problems, and in the United States the Presidential elections were approaching. Finally, the Arab world was publicly known to be far from united. For their part the Israelis were expecting an Egyptian attack and considered that their best chance was to forestall it by launching a preventive campaign.

During this critical week at the end of October many of the conditions necessary for the success of a military operation seemed to have been miraculously assembled. In launching her attack, however, Israel undoubtedly still ran two immediate risks.

- Counter-measures by the U.S.S.R., who, by sending "volunteers", could extend the conflict and turn the Middle East into a serious battlefield, on the Korean model.
- The application of the military agreements existing between the various Middle East States and the consequent necessity of fighting on all fronts in a combat whose extent and scope could not be predicted.

General Moshe Dayan's staff cannot be accused of having failed to understand the advantages of a lightning stroke, nor of having neglected to adapt their strategy and tactics to the needs of the moment. Neither the young Israeli General's thinking nor the execution of his orders were paralysed by military theories based on the lessons of World War II, theories which had already proved to be inapplicable to the new forms of localized conflict.

While Tel Aviv, spurred on by the constant mass threat to its existence, was working out its plan of operation, London and Paris were preparing a staff exercise. Textbook in hand, and accepting a whole range of premises whose validity could not be checked, the combined staff of General Sir Hugh Stockwell, Air Marshal Barnett and Vice-Admiral Burnford Slater bent over the "sand box" of the Eastern Mediterranean.

Cyprus, situated 250 miles from the Nile delta, would form the air base, and Malta primarily the naval base for the operation. Landbased bombers and fighter-bombers would be used to destroy the enemy's air units at their airfields. Aircraft carriers, with their *Sea Hawks* and *Corsairs*, would also take part. Then would come the transport aircraft based on Cyprus, followed by landing craft. Finally, troops would also be transported by helicopters, so as to try out all the capabilities of rotary-wing aircraft. "Suez" was to a combined operation, both inter-service and inter-Allied. The British took over command of the whole operation and of the land, sea and air forces, but the seconds-in-command were French. Thus all branches of the services would make their contribution, and all available weapons and techniques would be utilized. Helicopters would speed up landings, enemy radio communications would be jammed, and Egyptian tanks attacked with S. S. 10 guided missiles.

Chronologically, the two military objectives of the Anglo-French intervention were as follows:

- to gain mastery of the air by destroying the Egyptian aircraft, as far as possible on their bases;
- to occupy the Canal Zone by means of paratroops and landing forces that would be deployed along both banks of the waterway. The British would reoccupy the bases they held before the Anglo-Egyptian agreements.

Politically, the essentials were to act speedily, to keep losses on both sides to the minimum and to occupy a key territory with a view to negotiating its internationalization from the strength of a rapid victory. Colonel Nasser's prestige would be undermined, Israel freed of

French paratroops about to leave Cyprus for the Canal Zone.

British *Hunter* crew off on a strafing mission against Egyptian airfields.

Wounded are carried aboard a British hospital ship by an ambulance helicopter.

French paratroops and artillery in the attack on Port Said.

the threats of annihilation hanging over the young State, and the British position in the Middle East strengthened by this show of force.

As soon as Eden's ultimatum expired at 4.30 a. m. on October 31st, Nicosia announced the beginning of the first phase of the operation. R. A. F. *Valiants* and *Canberras* bombed Inchas, Abn Sueir and Kabnit. At the same time it was stated that a carrier force was approaching the Egyptian coast and air reinforcements were arriving at Limassol. The next day *Canberra PR. 7s* photographed the results of the raids, which had been extended to some ten airfields.

The French Ministry of National Defence published a communiqué announcing that the Egyptian Air Force was practically *hors de combat*. Actually some of the MiG-17s which had escaped the raids had left Egypt and taken refuge in Syria. Their arrival there started rumours of Soviet reinforcements and created the first feelings of uneasiness in Western capitals. A few days later there were reports, this time from the Israelis, that MiG-17s, accompanied by Soviet transport aircraft, had landed at Beirut. The news was naturally associated with the presence in Moscow of Syrian President Shrukri el Kuwatly. Once again the West was faced with the question of whether a Soviet-Arab operation was about to be launched from bases less than 150 miles from Cyprus. Whether true or false, the rumours of aircraft movements upset all calculations in the Middle East struggle.

Nevertheless, the staff exercise was running its course. The R. A. F. had gone back to its old pathfinder tactics. Targets were outlined by target indicators released from low altitude, and waves of bombers then came and aimed at the centre of the areas thus marked out. Opposition in the air (two attempts at interception) and by anti-aircraft artillery was weak or non-existent, so that the operation took place as if on the gunnery range. The task of the carrier-based aircraft was to patrol the coasts and if possible to destroy the Egyptians' cement-laden blockships before they were scuttled in the Canal. These raids were continued on November 2nd (bombing and machine-gunning of the Luxor airfield where Il-28s were stationed) and on November 3rd. As, by the latter day, mastery of the air seemed to have been fully attained, the British Command turned to destroying Egyptian Army installations. *Sea Hawks,* F-84Fs, *Avengers* and *Corsairs* began a campaign of encircling and wiping out enemy stores, radar stations, marshalling yards and tank concentrations in the Ismailia, Gizeh and Almaza areas.

This campaign continued until November 4th. Observers had expected two days of preparation, but here was already the fifth day. "Time Magazine" wrote: "The British and French had all but telegraphed their intention to make simultaneous airborne and seaborne landings at Port Said. Their execution was painfully slow. The invasion fleet, much of which had to make a three-day trip from Malta, spent at least 24 hours longer than necessary reaching Port Said—presumably they idled at sea during some hesitation in British diplomatic maneuverings. In the end, without simultaneous landings and without prior bombardment the British and French dropped in slightly over 1,000 paratroopers, who were left to take care of themselves for nearly 24 hours."

The hours wasted at the beginning apparently decided the outcome of the whole affair. The Air Force had taken unto itself the lion's share but had extended the exercise, while the Navy arrived too late.

It was not until the next day that the human pipeline thus laid down began to deliver. British helicopter-borne commandos were launched from Royal Navy vessels, while fresh paratroops gained a foothold in Egypt, and transport aircraft landed on Gamal airstrip. However, the real conflict was no longer taking place in Egypt, but between Moscow, Washington, London and Paris. Finally, while Allied Forces were pushing southward to gain as much territory as possible, the "cease-fire" put a stop to the operation before it had attained its real military objective, the occupation of the entire Canal Zone. Before the adversary had thrown up the sponge, the umpires had stopped the Blue side. The next step was criticism of the exercise.

It has been said that the "operation" had to be advanced by a week and that this unexpected change in plans was the reason for the delay in landing. Although defendable from the military standpoint, this explanation is dangerous from the political point of view. Either there was no collusion between Israel on the one hand and Britain and France on the other, and hence the "operation" could not be planned for a given day. Or there was agreement beforehand—an agreement which Israel did not stick to—in which case the Egyptian allegations of a "plot" are reasonable. In actual fact, the very slowness of the Anglo-French operations would seem to prove the absence of prior understanding and the truth of London and Paris statements on this subject.

Israel had no qualms about pushing forward during the first two days of her offensive without bothering too much about first destroying her opponents' Air Force, as laid down in the textbooks. The British and French, on the other hand, spent four days overcoming a more or less ghost air opposition, which in any case had ceased to form any real threat within 48 hours after expiry of the Eden ultimatum.

It has also been said that the whole intervention came too late, that, to be successful, it should have taken place immediately after the nationalization of the Canal. It is difficult to see how the Franco-British forces, taken by surprise by the Israeli action at the end of October, could have been ready at the beginning of August. The truth is that the Western democracies' combat resources are no match for the conditions of warfare on the Cold War fronts. These resources, the instruments of a peaceful and essentially defensive policy, have neither the mobility nor the long-range striking power required for military initiatives outside European territory.

What's in the Air?

Extracts from Interavia Air Letter, *daily international news digest, in English, French and German. All rights reserved.*

AIR TRANSPORTATION

● **The United States and the Netherlands** will resume negotiations on an air transport agreement in Washington next March 18th. The talks began last April, but were adjourned in mid-summer. Dutch officials have so far received no indication from the State Department that resumption of negotiations next spring will result in a more liberal U.S. policy towards K.L.M.'s request for extended routes within the United States. However, they were heartened by the fact that the State Department took the initiative in suggesting a date for resuming the talks.

● **The Deutsche Lufthansa** carried a total of 74,070 passengers, 550 tonnes of freight and 363 tonnes of mail during the 1955 operating year. Ten aircraft were employed on scheduled services. Operating revenue amounted to DM 23,600,000 in round figures, expenditure to DM 44,100,000. The deficit of DM 20,500,000 was covered by the Federal Government and the Government of North Rhine-Westphalia.—The annual report points out that 1955 cannot be regarded as a normal business year. The Allied authorities, which at that time still controlled the company's activities, had authorized the following operations in 1955: as from March 1st, trial services on domestic routes; as from May 15th, services to other European countries; as from June 8th, services to the United States. Operations were thus normal only during the second half of the 12-month period. Further expansion of the company is expected to require investments totalling DM 405,000,000 by 1961. The general meeting of shareholders on December 4th decided to increase share capital from DM 80,000,000 to DM 120,000,000.

East German Lufthansa fleet: seven Ilyushin Il-14s at Berlin-Schönefeld airport. In the foreground the tail of an Ilyushin Il-14 belonging to the Czech airline CSA.

● **Eli Linee Italiane S.p.A.** is the name of a new company formed by Linee Aeree Italiane, Aerolinee Italiane Internazionali and Fiat to specialize in helicopter services in Italy.

● **Braniff International Airways** proposes to issue up to $40,000,000 in 4.75% equipment mortgage sinking fund bonds. The funds will come from a group of insurance companies and will be used to buy new aircraft and equipment and for other company activities. Claude G. Adams, Vice President of Finance, explained that the company must raise a minimum of $35,000,000. The airline has on order 26 aircraft of various types, with deliveries running into 1959.

● **Panair do Brasil S.A.** has obtained a $6,900,000 loan from the Export-Import Bank of Washington to finance the purchase of four DC-7Cs and spare parts from Douglas Aircraft Co.

● **Qantas Empire Airways** will use two dollar loans totalling $27,000,000 to pay for the purchase of seven Boeing 707s, four Lockheed *Super Constellations* and aircraft parts. The Australian Government has placed $17,770,000 in notes, maturing in 1960 and 1964, with institutional investors and has arranged for a $9,230,000 loan, due in 1964—66, with the International Bank for Reconstruction and Development. Interest on both loans will be 4¾%.

INDUSTRY

● **Douglas Aircraft Co.** now holds little hope that the F5D *Skylancer* all-weather carrier-borne interceptor, for which the U.S. Navy has refused to grant a production contract, will ever reach full-scale production. The Navy's original pre-production contract for twenty aircraft was cut some time ago to ten, and Douglas has now cancelled plans to tool up for full-scale production at its Torrance plant. Construction of the contracted ten aircraft is, however, continuing. The Navy's decision not to grant a production contract "at this time" is believed to be due to lack of ready finance. Some sources point out that the Navy is spending so much on missiles and rockets that not enough is left over for production of both the *Skylancer* and the Chance Vought F8U *Crusader*.

● **Polverifici Stacchini S.A.,** of Rome, has been awarded a contract by the Japanese Government for 500 *Airone* air-to-air guided missiles. Some technical data: length 4.6 ft., weight 22 lbs., range 7 miles, electric proximity fuse actuated within a radius of 160 ft. from the target.

● **Emil Georg Bührle,** whose name enjoyed international fame far beyond the borders of Switzerland through his Oerlikon Machine Tool Works, Bührle & Co. and its many products, died in Zurich on November 28th, 1956 at the age of 66.

The story of this Swiss industrialist reads like a novel. Son of a South German civil servant and originally destined to study the history of art, Bührle served as German cavalry officer in World War I. In 1924, recently married, he moved to Switzerland to take over management of the relatively insignificant Oerlikon firm, in which his wife's family had obtained an interest. He acquired manufacturing rights to the Becker 20-mm cannon which was under development at the end of the war and made of it a small-calibre gun which, between 1930 and 1939, captured markets in Czechoslovakia, Japan, Britain, France, the United States and many other countries. By the outbreak of World War II Bührle was firmly established and a wealthy man. The war boom made him into an industrial power. His firm has innumerable subsidiaries, foreign branches and major investments outside Switzerland. Bührle products are to be foud in the fields of electronics, fire control equipment (Contraves), aircraft production (Pilatus), chemistry (Nobel Dynamit), as well as of office and knitting machinery and even in the hotel trade. The civil servant's son had become an industrialist and a financial power, with his own bank (Industrie- und Handelsbank Zurich A.G.).

At the summit of his career the former art historian returned to his early loves and became the biggest art collector in Europe, perhaps in the world.

He is succeeded by Dr. Dieter Bührle, 35, his only son, whom he had long ago familiarized with the complex threads of the family business in preparation for his future task.

● **Dr. Jean-Tony Lacour,** Professor of Transport Law at Geneva University, and a well-known authority on international air law, died of a heart attack on November 25th at the age of 57. Professor Lacour was President of the Swiss Air Law Association and member of the Swiss Aviation Commission.

● **British aircraft industry exports** are expected to total £105,000,000 for 1956, according to the Society of British Aircraft Constructors. The figure for the first ten months to October 31st was £89,351,882. During October alone, aircraft accounted for almost £6,000,000, engines £2,100,000, electronic equipment some £234,000, tyres £66,600 and instruments £144,000. During the first ten months of the year, the United States bought British aircraft valued at £13,600,000; Australia came next with £10,000,000, followed by Sweden with £6,100,000, France with £2,700,000, Belgium with £2,500,000 and the Netherlands with £2,100,000.

A Kaman HOK-1 helicopter as "flying fire engine" to combat crash fires in aircraft accidents. The helicopter carries a three-man fire-fighting crew and a transportable chemical fire extinguisher to the scene of the accident (left). During the rescue manoeuvre the pilot can direct the rotor downwash towards the fire to facilitate rescue of the aircraft occupants and extinction of the flames (right).

The Royal Canadian Air Force's No. 445 CF-100 Squadron has been posted to the N.A.T.O. base at Marville, France. Left, the departure ceremony at R.C.A.F. Station Uplands, near Ottawa; right the route from Canada to France.

● **Lockheed Aircraft Corp.** has announced the consolidation of all *Super Constellation* design engineering in one overall project and the appointment of Joseph P. Seamons as head of the new organization. Previously there had been two engineering teams—for the 1049H *Super Constellations* and the new long-range 1649A model.

● **Piasecki Aircraft Corp.** has reached an agreement with Bellanca Corp. under which it will acquire the assets of the latter's aircraft division at New Castle, Del., for $1,325,000. The New Castle plant has been used by Bellanca for the production of laminated plastics, radar antennae, engine mounts, nose assemblies and tow targets for the U.S. Air Force. The facility also includes a private airport with a 3,500-ft. runway.

● **Avco Manufacturing Corp.** will build a $15,000,000 research and development centre near Boston, Mass. Its main purpose, according to present plans, will be development of guided missile systems. The new facility, which is expected to be in operation about the middle of 1958, will house all research activities of the Guided Missile Division organized late in 1955 and now temporarily located at Lawrence and Everett, Mass. At present the division is concerned largely with research and development of advanced missile systems for the Department of Defense.

● **Beech Aircraft Corp.** has signed an agreement with the Argentine Government on the licence production of the T-34 *Mentor* trainer by the Government-owned I.A.M.E. works at Cordoba. The Argentine Air Force is said to be planning the acquisition of ninety T-34s, of which the first 25 would be bought direct from Beech Aircraft.

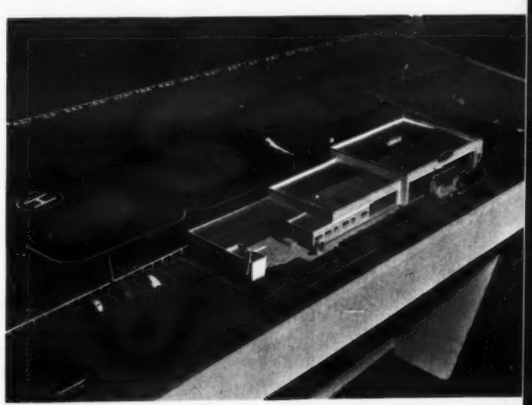
● **Proposals for a merger** between Amalgamated Wireless (Australasia) Ltd. and Email Ltd. are being examined by the two companies' directors, and there are strong rumours that AEI Ltd., another major Australian electronics firm, is also considering merger proposals with the same group. A merger of the three would form a very strong electronics group, with major contracts in the field of aviation electronics, including research work associated with guided missiles.

TECHNICAL

● *Bell Aircraft Corp.* is the sixth aircraft manufacturer to receive a project development contract for a "*Flying Crane*" *type helicopter* to carry very heavy or bulky loads. The contract, valued at $57,719, was placed by the Army Transportation Research and Development Command.—Earlier contracts for heavy "flying crane" helicopters went to Flettner Aircraft Corp., Kaman Aircraft Corp., Piasecki Aircraft Corp., the Aircraft Division of Hughes Tool Co., and Hiller Helicopters.—The U.S. Army specifications for this class of equipment call for a transport capacity of up to 15 tons over relatively short distances (up to roughly 100 miles). A special requirement is that "flying cranes" should be easy to maintain and extremely reliable even under very bad weather conditions.

● *The Bell XH-40 turbine-powered helicopter* has made its first hovering tests some time ahead of schedule and just 16 months after Bell had received a design contest contract. The Bell XH-40 will be ready for delivery to field troops in 1959; it will cruise at 100 knots and carry 1,000 lbs. payload. Power is provided by a 825 h.p. Lycoming T-53 free turbine engine.

● *Berizhev Be-6 flying boats* (N.A.T.O. designation *Madge*) are believed to be in operational use in considerable numbers. It is a twin-engine high-wing monoplane (two ASh-73 engines of about 2,000 h.p. each) with fixed wing-tip floats, twin rudder unit and a hull which apparently has not been designed according to the latest hydrodynamic theories. It is reported that a turbine-powered version of the *Madge* is in existence, designated Be-8.



Model of the heliport to be built in the grounds of the 1958 Brussels World Fair. It will be served regularly by Sabena helicopters.

● The U.S. Navy plans to proceed with production of the long-range *Martin P6M-1 Seamaster,* despite

Three new lieutenant generals in the Italian Air Force. Left to right: Sergio Lalatta, Commander of the 5th Allied Tactical Air Force in Vicenza; Giuseppe Casero, Director General of Weapons and Ammunition, Ministry of Defence (Air); Domenico Ludovico, Commander of the 4th Territorial Air Zone, Bari.

Air Marshal Sir Gordon Harvey has relinquished the post of Air Officer Commanding-in-Chief, Maintenance Command, R.A.F. and has joined G. Q. Parachute Co. Ltd.

George B. Shaw has been named President of Martin International, a new subsidiary of The Glenn L. Martin Co.

Lockheed Aircraft Corp. has appointed L. Eugene Root as Vice President and General Manager of the Missile Systems Division.

F. H. "Tom" Wheeler, founder and President of Wheeler Airlines, with the citation presented to him by the Air Industries and Transport Association of Canada on his company's 35th anniversary.

Four new Vice Presidents of Hughes Aircraft Co. Left to right: Clarence A. Shoop (Flight Operations), Roy E. Wendahl (Manager of the Tucson, Arizona, plant), C. Harper Brubaker (Planning and Programming), Edward M. Boykin (Field Operations).

Fernand H. Matile, formerly sales engineer with Brown Boveri Co., has been appointed Assistant General Manager of Lear S.A., Geneva.

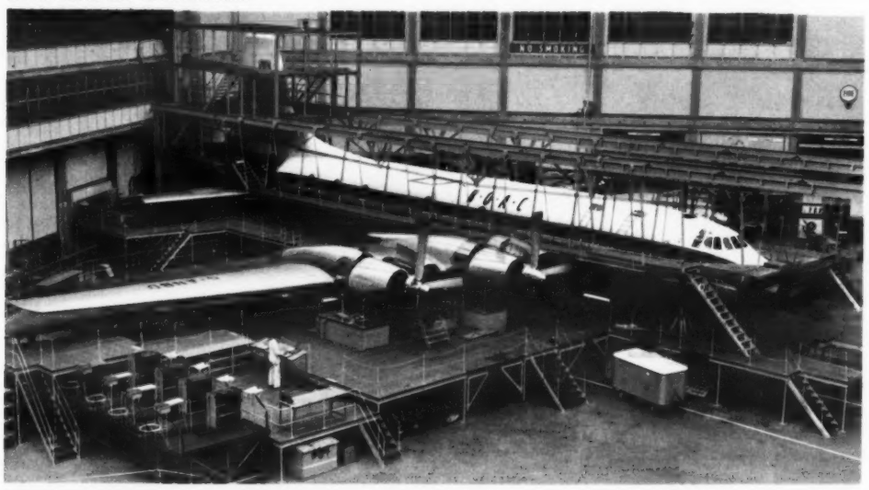
the recent crash of the second prototype, according to Rear Admiral J. S. Russell, Chief of the Navy Bureau of Aeronautics. Admiral Russell indicated the *Seamaster* programme had been "set back somewhat" by the crash because it leaves the Navy without a *Seamaster* for flight research. The third model (the "Y" or development model) is not scheduled to be finished until next spring.

● A third version of the *Douglas Nike* anti-aircraft missile is announced by the U.S. Army. It will be known as the *Zeus*. The two earlier-known versions, *Nike I* and *Nike B*, have been renamed *Nike Ajax* and *Nike Hercules* respectively.

● Three new wind tunnels, covering the transonic, supersonic and hypersonic speed ranges, have been added to the high speed laboratory of *United Aircraft Corp.'s Research Department*. All three tunnels, construction of which started in 1955, are of the blow-down type. The transonic tunnel can be operated through a range of Mach 0.5 to 1.5, the supersonic tunnel covers a Mach range of from 1.5 to 5, and the hypersonic tunnels operates from Mach 5 to Mach 10.

A Douglas DC-7C has made a non-stop flight on the 5,959-mile stretch between Long Beach, California, and Stockholm, thus setting up a new world distance record for civil aircraft. Flying time 21 hrs 41 mins 18 secs.

Maintenance dock for the Bristol *Britannia* in B. O. A. C.'s premises at London Airport. All parts of the aircraft are easily accessible from a series of fixed platforms. Normal overhead lighting is supplemented by fluorescent lighting for the underside of the aircraft.



● *The Deutsche Forschungsanstalt für Luftfahrt* (D.F.L.) has taken a cascade wind tunnel into operation at Brunswick-Waggum Airport. It will be used primarily for testing compressors and turbines. Power 1,300 kW, speed of flow 1,180 ft./sec, air mass flow 1,059 cu.ft./sec, top Mach No. M = 1.1, max. simulated altitude 25,590 ft., static pressure 1.4 to 14 p.s.i., pressure ratio 2.14, test section 0.98×0.98 ft.

● "*Weapon Able*", a new anti-submarine rocket, is to be used aboard U.S. Navy destroyers of the future *Leader* class. Older destroyers already in service are also to be converted to take the new weapon. The latter is initially to have a conventional warhead, but it is reported from several quarters that it could also be developed to take an atomic warhead.

● France's Office of Aeronautical Training and Sports Flying has decided to test the *Potez 4 D 31* supercharged engine of 220 h. p. on the *Stampe SV 4* biplane. The adaptation of the engine and the necessary modifications to the fuselage will be carried out by Constructions Aéronautiques Stampe et Renard, Belgium.

● The *Breguet 1050 Alizé* anti-submarine aircraft, flight testing of which began several weeks ago, is equipped with an undercarriage specially designed and built for it by Hispano Suiza. It is a tricycle undercarriage with five identical and interchangeable wheels. The nose wheel can be steered by the pilot and is retracted rearwards into the fuselage. The main units have two wheels each, retracted forwards into special nacelles under the wings. Shock absorbers are designed to facilitate deck landing in heavy seas. Weight has been kept down to a minimum by the use of special steels and light alloys.—Hispano Suiza also supplied all the hydraulic equipment for the *Alizé*, to steer the nose wheel, lower the arrester hook, brake the main wheels, retract the undercarriage, fold the wings, and operate the air brakes, flaps and bomb bay doors.

● The projected *Boeing and North American supersonic bombers* are designed for extensive use of titanium. In the Boeing project nearly 90% of the stressed airframe will be of titanium alloys. North American plans the construction of three prototypes, one principally of steel, the second mainly of titanium, and the third using steel and titanium in roughly equal proportions.—Present titanium stocks in the United States are not sufficient for production of the projected bombers, though titanium producers have promised a 50% rise in output by March 1957.

● It is understood that discussions have been going on between *Bristol and Boeing* over a new light-weight gas turbine with exceptional specific fuel consumption, for the projected Boeing 727 medium-haul jet airliner. Apparently, one of the big attractions of the new design is that it uses components and experience from other Bristol engines-most probably the BE-25 *Orion*.

● A first prototype of the four-engine *Agusta-Zappata AZ.8* feeder and short-range commercial transport is in final assembly; a second prototype is also being built.

SALVO AT 40,000

This split second in the RCAF's radar-controlled lead collision course attack technique demonstrates the most powerful weapon in air defence. Automatically released, a salvo of rockets from the Avro CF-100, packing the punch of a destroyer, *boxes the target in a lethal concentration of fire power.* Interceptor squadrons of the RCAF being equipped with the Mk. 5 variant of the CF-100 . . . capable of operational performance at high altitude . . . practice rocket firing day and night, as part of their round-the-clock alert.

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The Medical Problems of Supersonic Flight

by Prof. H. Strughold and Dr. S. J. Gerathewohl,
U.S.A.F. School of Aviation Medicine, Randolph AFB, Texas.

The two authors, Professor H. Strughold (left) and Dr. S. J. Gerathewohl.

The speed spectrum for flight within the atmosphere is divided into the following ranges : the subsonic range up to a speed of approximately 550 m.p.h., the transonic range from 550 to 850 m.p.h. and the supersonic range. Of late, the latter has been sub-divided into the supersonic and the hypersonic ranges, depending on differences in interactions between the aircraft and the air. In the lower supersonic range these interactions consist in essentials in the heat effects produced by stagnation and friction (aerothermodynamics). In the higher supersonic range, the hypersonic region, the boundary layer temperatures reach such high values that they lead to chemical effects in the form of dissociation and ionization of the air molecules (aerochemodynamics).

In aeronautical engineering the dividing line between the supersonic and hypersonic ranges is taken as a speed of Mach 5. In the case of flight beyond the mechanically effective atmosphere we leave the spectrum of aerodynamic or aeronautical speeds and arrive in the category of astrodynamic or astronautical speeds (orbital and escape velocities).

In the present article we shall restrict ourselves to discussion of the medical problems of the supersonic range in the aerodynamic speed spectrum.

*

It is obvious that, like technical problems, medical problems in supersonic flight are different in kind and more complicated than in subsonic flight. They arise primarily from the speed itself, from changes in speed in magnitude and direction, from aerothermal effects, from the high altitudes necessary for supersonic flight and finally from the conditions arising through failure of the aircraft and in escape measures. These problems will be dealt with point by point below.

The man-machine system

The overall problem of pilotage at supersonic speeds and the medical questions involved can be solved only if the relationship between man and machine is treated as a single whole. The modern supersonic aircraft is not just a machine operated by a human crew and unconditionally subject to its will, but a tremendously complex system in which man is only a part, and in which he has a given function to perform.

The machine itself appears to be already largely " humanized " : it has sensory and locomotive " organs ", a central electrical " brain ", tendons and wiring " neurons ", a " muscular " system (power plant, undercarriage and controls), also a " body ", " nose ", " skin " and the stressed " skeleton " for the airframe. Man and his role, environmental and working conditions, his intervention in the event of failure and rescue from emergency situations, can be discussed only in relation to the system as a whole.

In incorporating man into such a system allowance must be made for the limits to his capacities. For example, the position, size and equipment of the cockpit may not be based entirely on technical considerations, but must also bear in mind the number of crew members, their tasks and their safety. A system can only operate to optimum efficiency if no single part of it is neglected.

Visual perception

Human sensory organs are not designed to operate at supersonic speeds. The act of perceiving in itself takes a certain length of time, which already has a practical effect in view of the distances meanwhile covered in supersonic flight, even though this time is only fractions of a second. Because of this perception lag alone there is, in flight at three times the speed of sound, a " blind " distance (distance scotoma) of some 100 yards which is not perceived by the pilot. This means that two pilots who see each other at this distance and at this speed are in reality already on the same level.

If the object first appears in the peripheral field of vision, perception is further delayed by movement of the eyes, accommodation and pupil reaction. The perception lags in such a case average roughly 1.5 secs. During this time alone an aircraft flying at Mach 3 covers nearly a mile. The importance of this perception lag when it comes to recognizing a target, navigation and safety in general is sufficiently obvious from what has already been said.

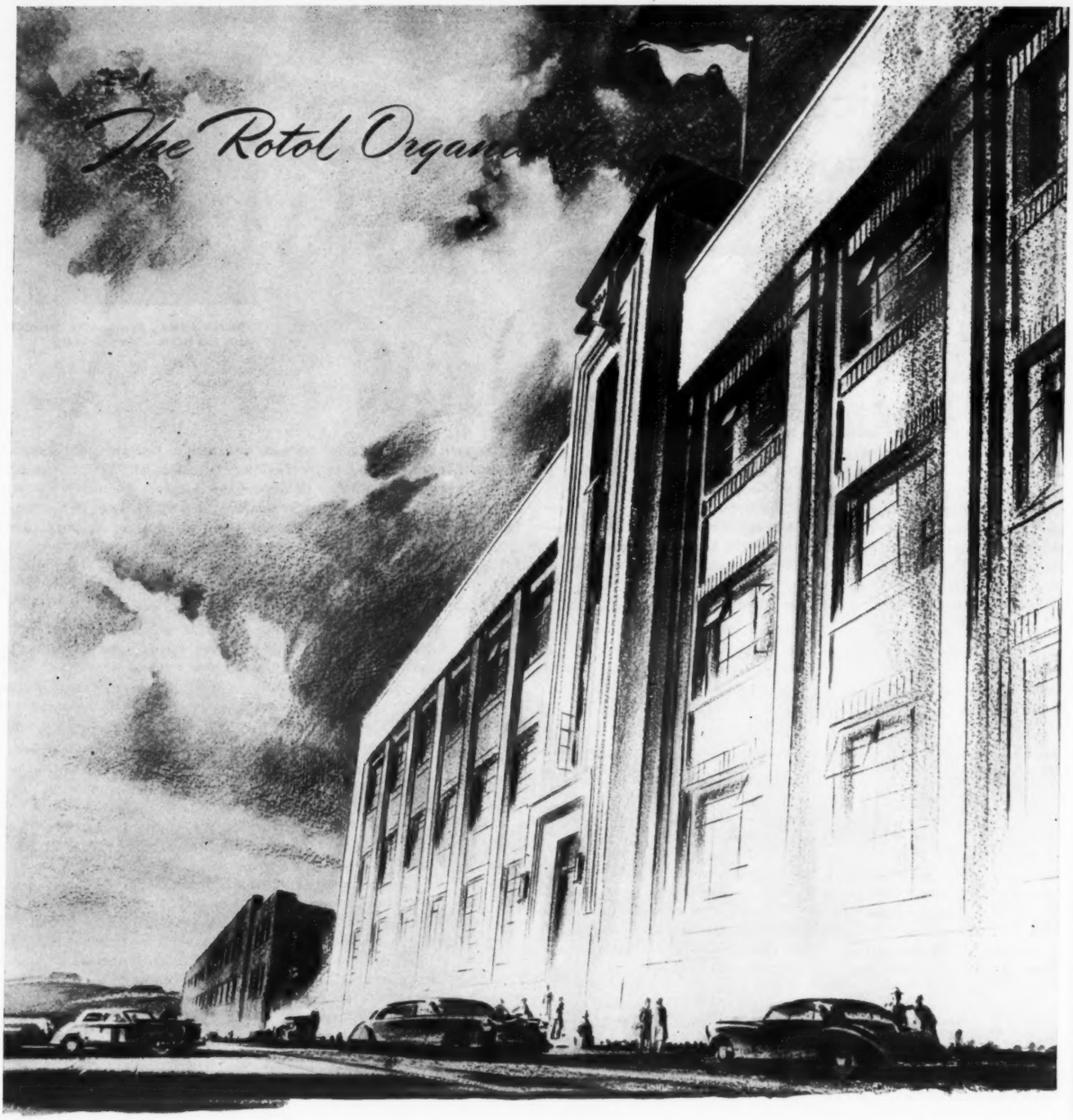
Another problem is the perception of motion. Moving objects are not clearly pictured on the retina and therefore appear blurred. Thus ground observations in high-speed flight can be made only from high altitude, when they are limited by the eye's resolving power. The inadequacy of our sensory organs and the human time constant, which takes effect as a perception and reaction lag, necessitate the use of artificial aids. These are telescopes and periscopes and above all radar, whose waves, travelling at the speed of light, increase the range of perception to the required degree. They also require the use of equipment that perceives changes in environment and flight conditions sooner, and reacts to them faster than man. And finally they demand the design of new airborne instruments so that the pilot can take those decisions and steps, that he cannot leave to the automats without undue delay.

Variations in speed

Speed can vary in both magnitude and direction. The effect of the forces thus arising on the human organism in subsonic flight is already well known. The accelerations occurring in supersonic flight are not so very different ; however, in tight turns they can reach values of up to 7 g and in flat turns are of longer duration because of the greater radius.

We know that magnitude, direction and duration determine the effect of acceleration on the organism and that—within given limits—greater accelerations can be borne the shorter their duration. Routine operations such as take-off, straight flying and landing entail no accelerations that necessitate the wearing of anti-G suits. In manoeuvres such as tight turns, spirals, pulling out of a dive and the like, anti-G suits must be worn ; they increase acceleration tolerance by 2 to 3 g. The provision of a comfortable, safe protective suit, which automatically responds to accelerations as they occur, is still an unsolved problem for supersonic flight.

One particular phenomenon appearing at very high speeds is the state of reduced weight. It arises in dives and in manoeuvres in which the centrifugal force set up by radial accelerations balances out gravity.



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Periods of several minutes of partial or complete weightlessness can be obtained in an aircraft flying at a speed of Mach 2 to 3, with a dive angle of 45° and with slight pressure on the stick.

The experiments so far carried out in this field have shown that men react to this state in very different ways. Slight coordination difficulties caused by weightlessness are overcome relatively fast. More serious psychosomatic disturbances, associated with loss of orientation and an autonomic "storm", were observed in a relatively small percentage of test persons. Experienced pilots were not hampered in the control of the aircraft itself by weightlessness. Frequent changes in accelerations hasten the onset of airsickness.

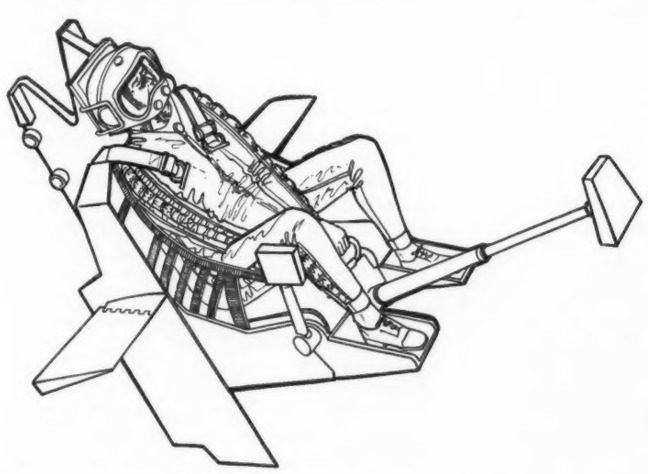
The heat barrier

The most important environmental factor in supersonic flight is undoubtedly temperature. It is, however, not the natural, low temperature of the various air layers that interests us here, but the high temperature produced artificially in the boundary layers of protruding parts of the aircraft by stagnation and friction. At Mach 2 and medium altitudes a stagnation temperature of 150°C is to be expected; at Mach 20 the boundary layers would have a temperature higher than that on the sun's surface.

This shows without further explanation that we are confronted with a serious problem. But it is primarily a problem for the engineer, since the basic rule must be that the machine is adapted to man and not the reverse. From the medical viewpoint it must be insisted that the cabin temperature should not exceed 25°C, and it is not permissible to calculate on the basis of the maximum temperatures a man can still just stand. Nevertheless, it is important to know what these maximum temperatures are, in case the cooling system fails. It is astonishing what high temperatures the human organism can tolerate for short periods. For example, it has been found in the test chamber that a temperature of 105°C in dry air can be tolerated for more than 20 minutes. Temperatures of 80°C could be withstood for 35 minutes, and of 70°C for more than an hour. These figures give some idea of the heat/time reserve available to man in an emergency.

For flights up to altitudes of 65,000 ft. and at moderate supersonic Mach numbers normal air cooling and ram air cooling systems suffice. The latter will be used primarily with ramjets which have no powerful compressors. At very high altitudes these cooling methods are no longer adequate. The most practical solution here, for relatively short flights, is special insulation and cooling of the skin with the aid of liquid oxygen. When we get to altitudes of 120 miles in a supersonic aircraft, aerodynamic heating ceases for all practical purposes because of the rarefication of the air. From here onwards the only outside influences determining the cabin wall temperature are the sun's radiation and the outer skin's absorption capacity.

The Lockheed *Model D* supersonic ejection seat is ejected downwards (from the Lockheed F-104 *Starfighter* interceptor). A metal helmet with thick glass face plate protects and restrains the pilot's head, while both hands grasp a low-set handle to protect the arms from injury. The legs are held in position by knee restraints and belts. The seat is stabilized during fall by means of stub wings (with aerodynamic airfoil) and enclosed in a shock wave cone produced by the airflow deflector plate—later retracted—in front (drawing by Ruth J. Turner).



High-altitude protection

Since, as shown in the preceding paragraph, the heat barrier loses its significance with increasing altitude, it is understandable that the supersonic pilot prefers the highest possible altitudes. But these present new problems. Firstly, conventional oxygen breathing becomes useless since the narrow altitude range within which this method is indicated can be passed through in fractions of a minute. The conventional pressure cabin is also an inadequate protection once altitudes of 80,000 ft. are exceeded. In its place a hermetically sealed cabin will have to be used, a completely enclosed cabin air-conditioned from inside. The same type of cabin is required as for space travel. Of course, a pressure suit can be worn instead or as well. If it has a ventilation system, it protects the pilot not only from high-altitude effects but also from heat accumulation.

Escape equipment

The speeds and altitudes reached in supersonic flight make bailing out a problem on which the engineer and the medical officer must work hand in hand. Simple jumping by parachute dates from the early low-speed aeroplane and is no longer of any use today. Instead ejection either upwards or downwards by means of explosive charges is used. Man's ability to withstand the accelerations and wind pressure effects thus arising has been thoroughly investigated during the past ten years. At speeds of up to Mach 1.5 and in medium altitudes the ejection seat with protection against the wind still offers adequate safety; with increasing Mach number and altitude the release of an entire enclosed capsule is the only solution. Such a capsule can be released either manually or automatically; in the latter case an emergency detector sets off the series of escape measures, namely separation, extension of stabilizing surfaces, opening of parachute and actuation of landing mechanism. The capsule must, of course, be buoyant and be equipped for rescue at sea.

Day-night cycle

So far we have discussed only problems arising during supersonic flight, but should close with a brief mention of a phenomenon with which we have to deal both during and after long-distance supersonic flights. In flights along the same degree of latitude, even at subsonic speeds, more than five or six time zones can be flown through in a single day. At supersonic speeds this will take only a few hours. In this way pilot and passengers will find themselves relatively suddenly in a place where the local time differs by more than a quarter of a day from that of their point of departure. The human body and its various functions cannot immediately adjust itself to the new local time, but requires several days to accustom itself physiologically. This phase shift between geographical and physiological time is of some importance in the case of passengers travelling at supersonic speeds to attend political or economic conferences, who may well arrive feeling tired despite the fact that, by local time, they should be fully awake.

In his flights in all directions over the globe the supersonic pilot cannot count on an ordered sequence of day and night, so that some artificial means of regulating day and night rhythm must be found in the interests of flight safety and to avoid chronic fatigue. In the age of supersonic flight the earth can no longer be regarded as the "terra firma" of the ancient Romans and Greeks, but as a planet moving round the sun and rotating about its own axis.

General... but One-sided Disarmament?

On November 18th, a few hours after the seismographs had recorded a fresh Soviet nuclear explosion, Marshal Bulganin transmitted a new disarmament proposal to the heads of the governments of the United States, Britain, China, France and India.

The well-worn themes of Soviet disarmament policy made their usual appearance in these notes, but for the first time the Kremlin accepted some of President Eisenhower's proposals for mutual air reconnaissance. The acceptance was only partial, since it suggests aerial inspection only in a zone of 500 miles on either side of the Iron Curtain.

The first proposal in the Soviet note aims at a reduction in armed strengths to a maximum of one million men under arms for each of the " Big Three " (United States, U.S.S.R. and China), 650,000 men for the two medium powers (Britain and France) and 150,000 to 200,000 men for other countries. It will be noted, in passing, that this proposal grants the advantage of numbers to the Eastern *bloc* with its satellites. Moreover, heavily populated countries such as West Germany and Italy would each have only 150,000 to 200,000 men, or less than a third of the strength allowed to France...

Article 2 of the Russian plan calls for a ban on nuclear weapons, including destruction of existing stocks and a stop to all further production. On this point the Soviet position has not changed. This is readily understandable, since the Eastern *bloc* has a population of nearly 1,000,000,000 in the Eurasian territories, that is to say, in a single geographical land mass. The ban on nuclear weapons would rehabilitate the value of numerical strength and place the 200,000,000 Western Europeans entirely at the mercy of the Communist world. There is little chance of such a proposal being accepted, despite the fact that it attracts the masses, who are increasingly anxious to see highly destructive weapons outlawed.

Next, the Soviet note tackles the stationing of troops in Germany. It suggests that American, British and French forces in West Germany should be cut, with Soviet units in East Germany being reduced in the same proportion. This would leave only the 200,000 men authorized under Article 1 to defend the safety of the Federal Republic and would above all tend to force the withdrawal of American troops from Western Europe. The United States' undertaking to defend Europe would no longer be backed by the presence of American units, and the forces remaining would be so disproportionate that political, if not military, absorption would be inevitable.

In the same spirit the Soviet proposals demand a reduction in N.A.T.O. strength and offer, in compensation, a parallel cut in Warsaw Pact forces.

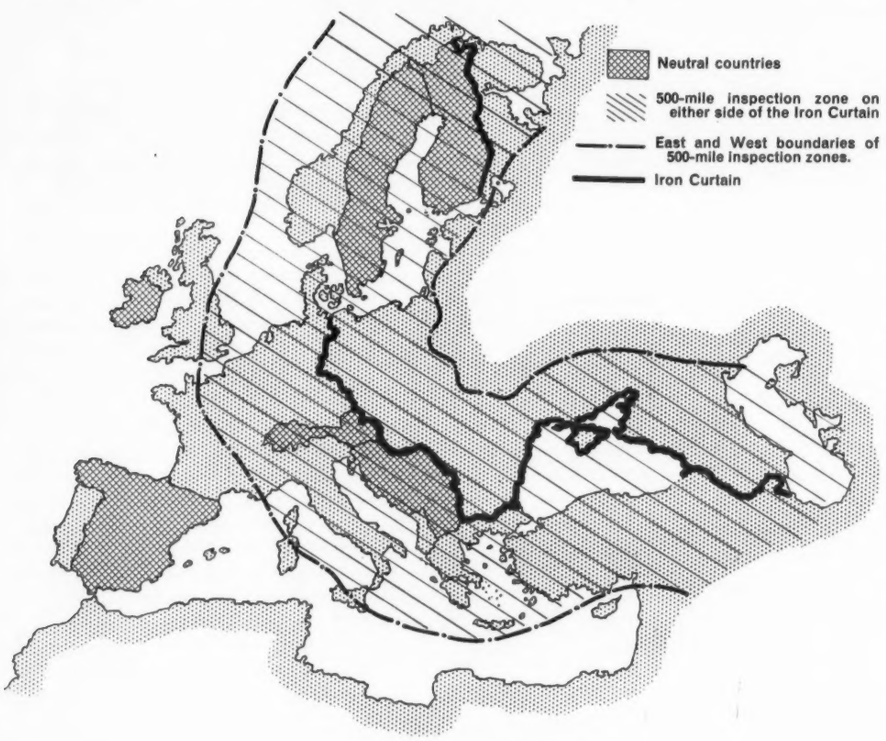
Article 5 aims at the liquidation within two years of all military bases in foreign countries. The whole American policy of deterrence is based on the threat of instantaneous retaliation from bases not only on American territory but also in Europe and Asia and round their periphery. To liquidate these bases would mean undermining the whole efficiency of a defensive system based on a wide dispersion of reprisal forces. If the United States gave up these advanced bases, it would inevitably be thrown back upon itself and would cease to envisage the use of its reprisal power unless U.S. territory was itself attacked. Thus Articles 3, 4 and 5 are interconnected. All have the same ultimate object : to destroy the West's defensive system, lead the United States into a new isolationism, and expose a weakened and isolated Europe to political penetration and the threat of military intervention.

Once this " reorganization " of Western forces is complete, the U.S.S.R. has no objection to an " effective and strict " control being instituted. In this way the disproportion in forces created by the proposed disarmament agreement would be maintained. The control measures accepted by the U.S.S.R. include a partial agreement to the ideas which President Eisenhower put forward at the 1955 Geneva Conference. The U.S.S.R. declares itself prepared " to examine the problem of applying aerial inspection in the zones in which the main N.A.T.O. and Warsaw Pact forces are stationed in Europe, to a depth of 500 miles east and west of the demarcation line, provided the countries concerned agree ".

What are the motives of this unexpected change in the Soviet attitude ?

This is an apparent concession to President Eisenhower's wishes, designed to cancel out Washington's preliminary requirement for any serious discussion of disarmament. The concession is only partial and does not remove the U.S. Government's concern in the face of the threat of a surprise aero-nuclear attack. With the growing range of strategic aircraft and the coming widespread introduction of long-range missiles, the mutual inspection of a strip of territory 500 miles wide would obviously offer very little guarantee. This is particularly true in that, on the Soviet side, the territory open to aerial inspection would concern only the satellite countries where long-range bomber units cannot be deployed or launching ramps for long-range missiles set up.

The air inspection zones as described in the Russian disarmament proposals. Basically the inspection zones should be 500 miles deep on either side of the " demarcation line " (Iron Curtain). As, however, the position of Finland and Yugoslavia in relation to the East and West alliances is not entirely clear, the width of the zones as shown in this map is not constant.


Neutral countries
500-mile inspection zone on either side of the Iron Curtain
East and West boundaries of 500-mile inspection zones.
Iron Curtain

The evolution of the political situation in Central Europe may also partially explain the Soviet proposals. Events in Poland and Hungary have clearly revealed that the U.S.S.R. is having difficulties with its subjugated satellites. While it would be morally indefensible and politically inept to take nuclear reprisals, in the event of war, on countries which are held within the Soviet orbit by force, it would be equally risky for the Soviets to gamble on the unconditional support of these countries. Hence these territories are in the process of being neutralized, since they cannot be made the target for reprisals or be used as bases for a military offensive against the West. In this case it is understandable that the Kremlin should agree to free aerial reconnaissance over such a strip of territory, particularly since, in exchange, it would get the right to exercise the same control in West Germany, the Benelux countries, France, Italy, Greece and probably Turkey—countries with their backs to the sea and with no other direct support but their own forces.

It will be noted that this Article 7 on aerial inspection would be devoid of meaning if the other Soviet proposals were accepted. As con-

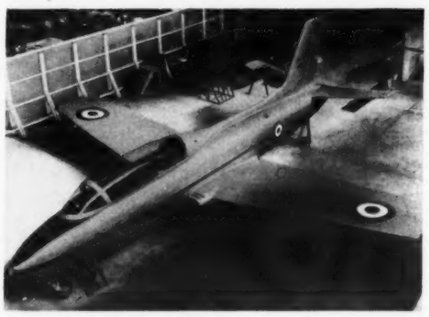
ceived by President Eisenhower, aerial inspection was designed to limit the possibility of a surprise attack (provided such inspection covered the whole of U.S. and Soviet territory). But a surprise attack would scarcely be possible unless it were based on the mass employment of nuclear weapons. Since the latter are banned under Article 2, there would be no reason to fear a surprise attack, and aerial inspection would become pointless. It would certainly be of no use as far as Europe is concerned, because even if it did detect sudden troop movements from east to west, these troops would obviously have reached their European objectives before forces stationed across the Atlantic had time to come to Europe's aid.

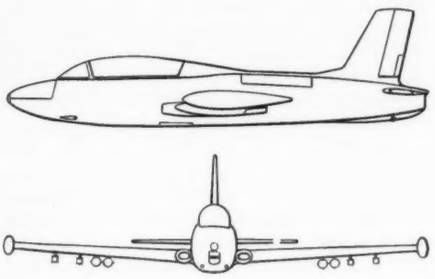
Finally, the Soviet proposals should be examined in the light of technical progress in armaments, particularly in long-range missiles. If it proved impossible to organize an effective check on whether the ban on the production of nuclear weapons was being respected, the threat of a surprise attack would remain. And even if the check on atomic explosives were entirely efficient, a threat to rain down non-nuclear intercontinental missiles on Western cities would still constitute a powerful means of political pressure, as proved by a recent example.

The experts will undoubtedly have separated technical realities from propaganda in these new Soviet proposals. Even a brief analysis suffices to show that Soviet interests are in no danger of being sacrificed on the altar of disarmament.

MB. 326 A Jet Trainer for Basic Military Training

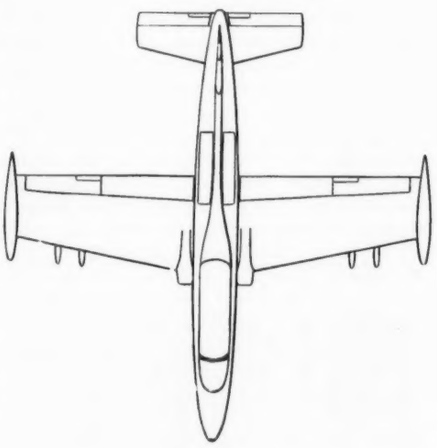
The question of whether military flying training should begin immediately on jet aircraft or include a preliminary period on piston-engine trainers has not yet been decided, though it may be assumed that ultimately all air forces will decide in favour of all-through jet training. Experiments have already been made with training French and British pilots in special elementary courses on jet trainers (Fouga CM. 170-R *Magister* and Percival P. 84 *Jet Provost*), and the Royal Canadian Air Force is reported to have decided to go over to training on jet aircraft only.





In order to meet the expected demand, *Aeronautica Macchi*, of Varese, Italy, has developed a light two-seat jet aircraft, designated MB. 326 and possessing the performance and flying qualities required for the first and second training stages. Its take-off wing loading of roughly 29 lbs./sq.ft. is sufficiently low, and its good aerodynamic design gives max. speeds of around 435 m.p.h. An MB. 326A version for gunnery training, capable of carrying two machine guns and four training rockets (or training bombs) without notable loss in performance, is also planned. — Power plant is an Armstrong Siddeley *Viper ASV. 8* of 1,750 lbs. take-off thrust.

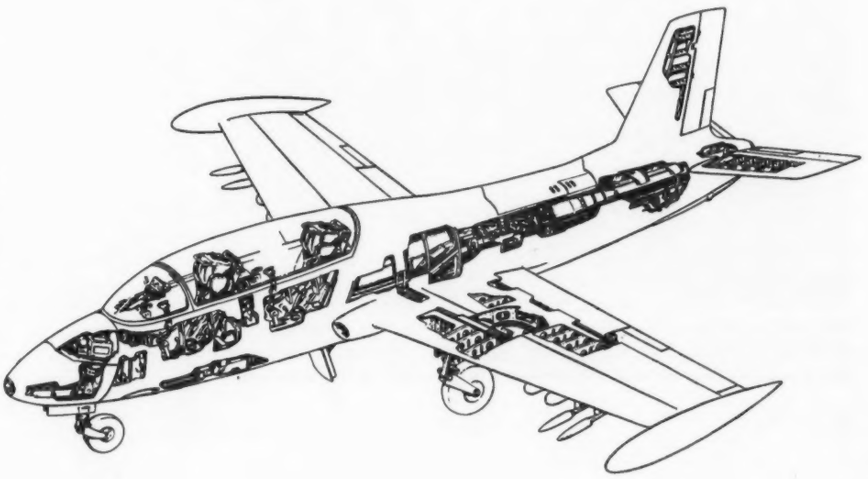
The MB. 326's structure can be described briefly as follows : all-metal monocoque fuselage with one-piece plexiglas hood for the two pilots' seats in tandem ; hydraulically operated air brakes underneath the fuselage. — Single-spar, three-piece all-metal wing unit with NACA series 64 laminar airfoil, consisting of two outer wings and a centre section running through the fuselage ; hydraulically operated Fowler flaps ; twin-spar elevator and fin unit. — Hydraulically retracted three-wheel undercarriage (nose wheel retracted forwards into the fuselage nose, main wheels folding outwards into the wing) ; oleo-pneumatic shock absorbers. — Electric system fed by two parallel accumulators of 24 V and 35 Ah, charged by a 1,500-watt generator coupled with the engine.



In addition to complete blind flying instrumentation, pressurization and oxygen equipment, equipment will include a SARAM 5-22 VHF transmitter-receiver and a Lear ADF 14 radio compass.

Data and design performance of the MB. 326 A armed version
(figures provided by the manufacturers)

Span	32.8 ft.
Length	33.8 ft.
Aspect ratio	5.26
Wing area	204.5 sq.ft.
Weight equipped	3,800 lbs.
Military payload	2,150 lbs.
Gross weight	5,950 lbs.
Max. engine thrust	1,750 lbs.
Max. speed at 9,840 ft.	420 m.p.h.
Max. speed at 29,520 ft.	448 m.p.h.
Stalling speed with flaps extended	82 m.p.h.
Rate of climb near ground	3,050 ft./min
Max. endurance with normal fuel capacity (189 Imp. gals.)	
at 9,840 ft.	1 hr 50 mins
at 29,520 ft.	2 hrs 10 mins
Take-off and landing distance over 50-ft. obstruction	720 yards



SITUATION REPORT FROM BONN:

Clearing out the Lumber

Lufthansa: an old name in search of new men

The delegates of the Federal Transport Ministry's Aviation Section returned from South America, after talks with the Argentine and Brazilian authorities, in the autumn of 1956. Thus, as *Interavia's* German correspondent puts it, the " Civil Air Defence Comrades Club " is reunited in Bonn. On his return, Ministerial Director Dr. Knipfer, head of the Aviation Section, and " President of the Civil Air Defence Club ", was welcomed with the news that there is no seat free for him on I.C.A.O.'s Jet Transport Committee, so that he will be able to continue to devote himself to the work of his department.

His Minister, Dr. Ing. Hans-Christoph Seebohm, had meanwhile made some very frank statements to the Parliamentary Transport Committee on experiences in rebuilding German air transport. Hopes placed in the effect of the good old name of Deutsche Lufthansa and in the profitableness of the North Atlantic route, he said, had proved sadly unfounded. It has also been found that " the twin-engine Convair 340, on the one hand, did not meet the public's wishes, and the four-engine Lockheed 1049G, on the other, did not come up to technical and economic expectations. " If the Minister's latter statement is correct, the equipment so far procured for the Lufthansa is proof positive of faulty planning. But there is a large number of major and successful airlines throughout the world who are entirely satisfied with similar equipment. Does the fault therefore really lie in the aircraft? ... Or should the blame perhaps be laid on the men rather than the machines ?

At any rate the members of the Transport Committee are now reportedly agreed that greater attention must be paid to the German national airline. The Foreign Minister has also taken a firm stand on future air transport policy in a circular to the Ministries concerned, since certain measures taken by Ministerial Director Knipfer appear to have seriously disturbed relations with foreign countries.

Meanwhile the Lufthansa published its third annual report (for 1955) on December 4th, 1956 and received approval from the General Meeting for an increase in share capital from DM 80,000,000 to DM 120,000,000 and for conclusion of a $10,000,000 loan agreement, at a " very favourable " interest rate, with the Chase Manhattan Bank ... " to continue organic build-up of the company."

The word " organic " sounds somehow comfortable, conjuring up a picture of the sheltered existence led by a child of well-to-do parents. The parents—the Federal Government with 72.3% of the capital, the Federal Railways with 4% and North Rhine-Westphalia with 7.5%—are in fact well-to-do. Moreover Federal Finance Minister Dr. Schäfer, usually somewhat close-fisted, is said to have confidence in Lufthansa's estimates and to be prepared to grant additional financial aid. Parliamentary Deputies, however, and in particular the Transport Committee are more sceptical. Parliamentary circles suggest that a stronger participation of private capital in the Lufthansa would be preferable to unrestricted control by the State and its civil servants, that the company is still under-capitalized, but that private capital can be attracted only if investors are given a real voice in the management and in the choice of the leading executives. Organic build-up ? Of what use are DM 80,000,000 in new funds, when the four Boeing 707's on order, together with their spare parts, will alone swallow up DM 120,000,000 ? Particularly when it is considered that, though four such aircraft would be sufficient for a smaller airline, they will not meet the requirements of Lufthansa's route plans and its former reputation.

For the past three years Lufthansa has been working at a loss—a loss which in 1955 amounted to roughly DM 20,000,000 on a capital of DM 80,000,000. A similar result is expected for 1956.

Nobody is entitled, however, to deny the new Deutsche Lufthansa every prospect of success. After a ten-year lapse the rebuilding of such an enterprise is certainly no easy task. But everything would have gone much more smoothly if certain obvious prerequisites had not been simply overlooked. The West German Federal Republic's Lufthansa—it may be noted in passing that it has a sort of step-sister in the East German People's Republic—was in an unusually favourable position on its rebirth: it was free of all dead weight in the form of old equipment. The revival of the name of Lufthansa was soothing to German eyes and ears. And other countries were quite willing to act as godfathers ; having already observed the German economic miracle, foreign interests were anxious to be on good terms with the new economic factor.

What went wrong during the build-up period ? Sooner or later it must be openly admitted that it was not an unfavourable constellation or a lack of funds which hampered Lufthansa's first development stages, but faulty planning, a kind of civil service dictatorship, lack of interest by private capital and finally an unusually unhappy hand in the choice of the men who were to be responsible for German air transport. The Minister appointed his party secretary to the Aviation Section, who brought with him experience of the old Luftwaffe staff. As he lacked experience of his new province, he recommended that the Aviation Section be headed by a man who, although a former member of the old Lufthansa's Board, was first and foremost a civil air defence expert. Not surprisingly, he in turn surrounded himself with his old civil air defence colleagues.

As in major, so in minor details. The national airline was also staffed, in some instances, less on the principle of the " right man in the right job ", but—as can sometimes happen in civil service departments —on that of the most convenient man in the most convenient job. Commercial Director Bongers is a bachelor of commerce and thus undoubtedly possesses the knowledge required to draw up a budget, calculate costs and prepare *overall* plans. However, he should have been backed, in the fields of operations, technical planning and relations with other companies, by men who are experts in these domains, as is the case in other leading airlines.

Admittedly Lufthansa began its operational planning with a first-class expert, a member of von Gablenz's old school who had been the old Lufthansa's Atlantic Chief Pilot. But Hans Werner von Engel soon departed, as he could make no headway. As he himself put it, he could not cope with the " civil service spirit ". Today he is lost to Lufthansa, having found his niche with General Dynamics Corporation and its subsidiary Canadair Ltd.

Then there were a number of young German pilots who had been taken on by Swissair and others during the period when flying was banned in Germany. Some of them had meanwhile become aircraft captains, others had advanced to senior administrative posts. They would willingly have switched over to the new Lufthansa, but they were not wanted, as their knowledge and experience would have made them awkward colleagues. Old Lufthansa members were also passed over, because most of them were more or less of advanced age and would have constituted a burden on the company's pension fund. Instead the " powers that be " made do with younger, cheaper staff. All that was fundamentally retained of the old Lufthansa was the name and the august Board Chairman. As, however, 85% of the capital was Government owned, the rest of the Board was filled up with civil servants.

All this may possibly change after the elections later in the year. An important point is that the Parliamentary Transport Committee has already turned its attention to the personnel problem and is on the look-out for new or

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" old " men. Lufthansa's third annual report speaks of " organic build-up ". The odds are that this will not begin before 1958.

Defence Ministry: a new Minister brings new life

Let there be no mistake about it, ex-Defence Minister Theodor Blank is a man of the highest esteem. To appoint him Defence Minister, however—as nobody inside or outside Germany will deny today—was not an entirely happy inspiration. His successor, the Bavarian Deputy *Franz Joseph Strauss*, West Germany's first Atomic Affairs Minister, took over a thankless task in mid-October 1956. If he succeeds in holding his own—which seems possible—he may well develop into the most awkward member of the present and doubtless the next Cabinet. He has not only to build up anew, he must first clear away the lumber. His predecessor spent five years preparing plans, all of which have since proved useless.

Interavia's German correspondent writes : The critical tensions in Eastern Europe and the Middle East do not leave the citizen of West Germany untouched. Suddenly the successes of the reconstruction period or the German economic miracle no longer seem to be an absolutely safe possession, but something that might have to be defended. At any rate rearmament is now more popular than it was a few years ago. There is no longer any conflict about " whether ", but only about " how ". And the new Federal Defence Minister is credited with having very definite ideas about this " how ". In his case, almost more than in that of any other Cabinet Minister, the 1957 election year is extremely important. As a politician he naturally wishes to be re-elected ; as Defence Minister he wishes to continue in the post which he has but recently taken over. Young in years and physically fit, cultured and politically versed, eloquent and always prepared not to withhold the truth, he enjoys a definite political credit. His brief period as Atomic Affairs Minister speaks in his favour, and his first press conference as Defence Minister received open approval from the usually sceptical Bonn journalists.

" Make the best of it " will have to be the new Defence Minister's slogan. His predecessor's mistakes force him to plan anew : reduction of the 500,000-man army originally promised to N.A.T.O. to a strength of 320,000, rationalization of the swollen ministerial organization, and introduction of general conscription from April 1st, 1957.

Once these preliminary tasks are completed, Strauss will be able to tackle the rearmament programme proper. Here he appears determined to push through his arms policy against the military ambitions of certain of the General Staff officers. To strengthen his political backing he is in the process of activating the Federal Defence Council, which was created two years ago but has since been condemned to impotence. The Council is to serve as a control authority and support the Defence Minister in the execution of his decisions. Like Clemenceau, Strauss believes that " war is much too serious a matter to be left to the military."

That he also intends to cooperate with the generals is proved by his attitude to *Lieutenant General J. Kammhuber* (Air Force), who is said to have been picked out as future *military Under-Secretary*, with the rank of a four-star general. Dr. J. Rust, the civilian Under-Secretary taken over from the previous Minister, also spoke about resigning when Minister Blank withdrew, but it may be that Strauss can persuade him to stay on.

Meanwhile a reorganization is already taking place in the Ministry : *Lieutenant General A. Heusinger*, at present head of the military command staff, appears to be in mind for a responsible post on the N.A.T.O. Standing Group in Washington, and an important job with the Allied Forces, Central Europe, has been earmarked for *Lieutenant General H. Speidel*. Who will replace General Kammhuber as Commander-in-Chief of the Air Force if he becomes Under-Secretary for Defence still remains to be decided.

•

A summary inventory of German defence preparedness reveals the following picture :

— The seven Army divisions to be formed by the end of 1957 will probably be ready on time.

— The Air Force has reasonable prospects of accomplishing the training programme prepared for it up to 1960. For the time being its procurement programme is based primarily on training requirements, so that the Training Command at Fürstenfeldbruck, Bavaria, becomes of central importance.

— As regards air defence, all ground anti-aircraft formations, contrary to original plans, will be attached to the Air Force rather than the Army.

It may have been noted that so far little or no reference has been made to the relations between German rearmament and the North Atlantic Treaty Organization. Strauss can certainly be regarded as a convinced supporter of the West, and it is no less certain that he will respect N.A.T.O. wishes in rearming Germany, insofar as he finds this feasible. Needless to say, however, he will not neglect the Federal Republic's regional defence interests.

The views of West Germany's citizens on the subject are illustrated by the following statement from the widely-circulated weekly *Der Spiegel* : "... What protects us is not primarily our membership in N.A.T.O., but the fact that the United States would no more accept an occupation of the Federal Republic than the intervention of Russian troops in Egypt. We are protected by the atomic balance between the two Powers... It is up to us to act as Europeans by arming discreetly..."

The first real rearmament of the West German Federal Republic will now begin. Its guarantor is no longer Adenauer, but Franz Joseph Strauss.

To avoid "stumbling" into the jet age . . .

The Jet Age Task Force set up by Tenth Session of the I.C.A.O. Assembly to prepare for jet transport and presided over by I.C.A.O. Council President Dr. E. Warner, has now held its first meeting in Montreal. After examining a report on air traffic control problems throughout the world, the committee decided to give first priority to the North Atlantic region, for the following reasons : the situation above the North Atlantic is characterized not only by an exceptionally high traffic density, but also by the need to maintain very great separations between aircraft because of the difficulties of radio communications in the Arctic regions with existing equipment. This already leads to substantial delays on the Atlantic routes, and the introduction of jet transport will make the situation even more difficult. — The second meeting of the Task Force, to be held in Paris in January, will consider the air navigation situation in the European-Mediterranean Region.

The picture on this page shows the members of the I.C.A.O. Task Force. Left to right: P. C. Armour (Deputy Secretary), René Lemaire (France), T. S. Banes (Secretary), Jerome Lederer (U.S.A.), Dr. Edward Warner (President of the I.C.A.O. Council and Chairman of the panel), A. P. Dekker (Netherlands), Helio Costa (Brazil) and Luis de Azcarraga (Spain).

Book Reviews

Nauticus 1956. Edited by Kapitän zur See Alfred Schulze-Hinrichs.—E. S. Mittler & Sohn G.m.b.H., Darmstadt, 1956 (German, 234 pages, price DM 15).

The introductory chapter to this handbook on shipping and world economy, now published for the thirtieth time, is devoted to the reconstruction of the German merchant navy and air transport. Discussion of general world economic questions is followed by a naval survey with details of new warship types and the strength of Western and East *bloc* fleets. A special chapter contains contributions on under-water detection and navigation in polar regions. Finally there is a 27-page statistical appendix with tables of tonnage and cargo capacities of the world's merchant fleet and a survey of world trade. Re.

Books received

Die Verkehrsentwicklung des Landes Nordrhein-Westfalen — 1. Vierteljahr 1956. — Published by the North Rhine-Westphalia Minister of Transport and Economy. Report No. 28, June 1956.

Publications scientifiques et techniques du Ministère de l'Air. — Distributed by the Service de documentation et d'information technique de l'Aéronautique, Paris :

No. N.T. 61 : *A propos de quelques expériences récentes sur la convection de la chaleur et la transformation de l'énergie*, by Pierre Vernotte.

No. N.T. 62 : *Contribution à l'étude de la combustion des bases pyridiques*, by Jean Ploquin.

No. 316 : *Sur la désorganisation et la restauration à froid de cristaux d'aluminium soumis à des tractions faibles*, by J. Caisso.

No. 317 : *Opérateurs symboliques*, by Henri Pailloux.

No. 318 : *Recherches sur la combustion d'un mélange d'hydrocarbures*, by Jean Rappeneau.

Air is in the Air. — Published by The Hymatic Engineering Company Limited, Redditch, Worcs., England, 1956.

Die Bestimmung der Flugzeugpolaren für Entwurfszwecke, 1. Teil : Unterlagen. — By Dipl.-Ing. D. Fiecke. Report No. 15 published by the Zentrale für Wissenschaftliches Berichtswesen, Deutsche Versuchsanstalt für Luftfahrt e.V., Mühlheim, Ruhr. Westdeutscher Verlag, Cologne and Opladen, 1956 (price DM 52).

Entwicklung und Stand der Luftnavigation. — By Dr.-Ing. E. Rössger. Report No. 25 in the series of technical and economic reports issued by the North Rhine-Westphalia Ministry of Transport and Economy. Printed as manuscript, 1954.

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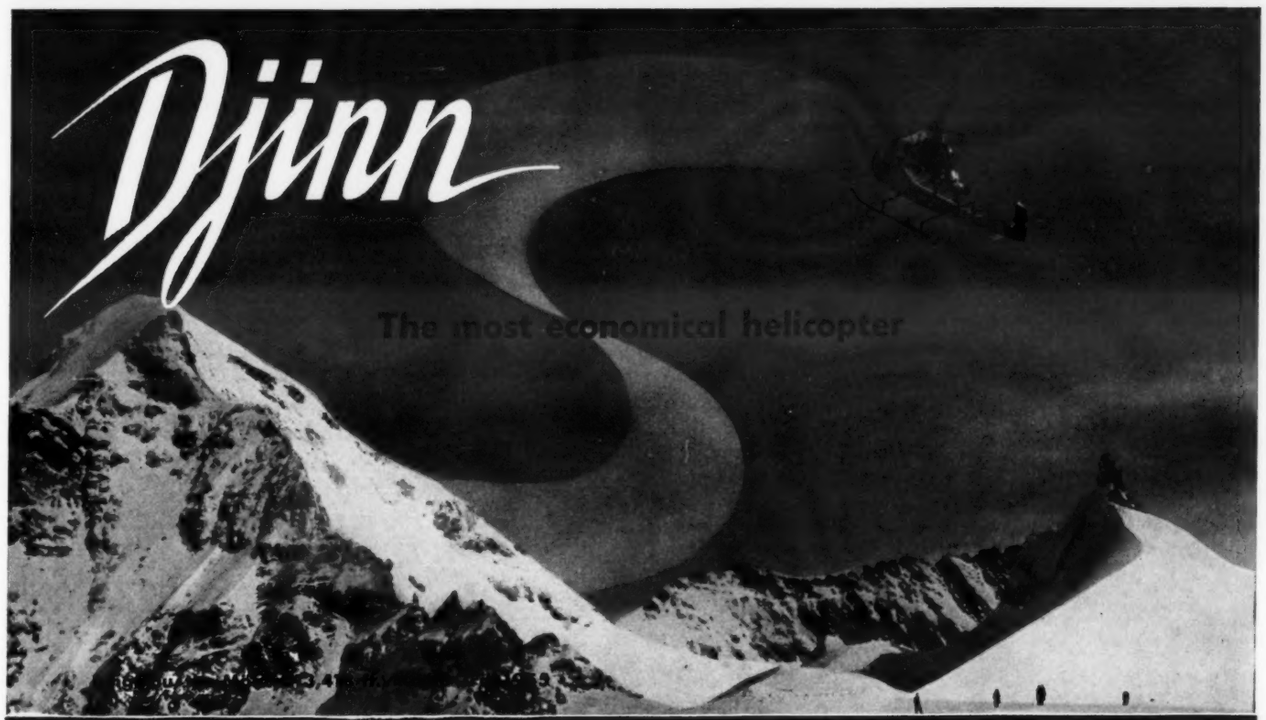

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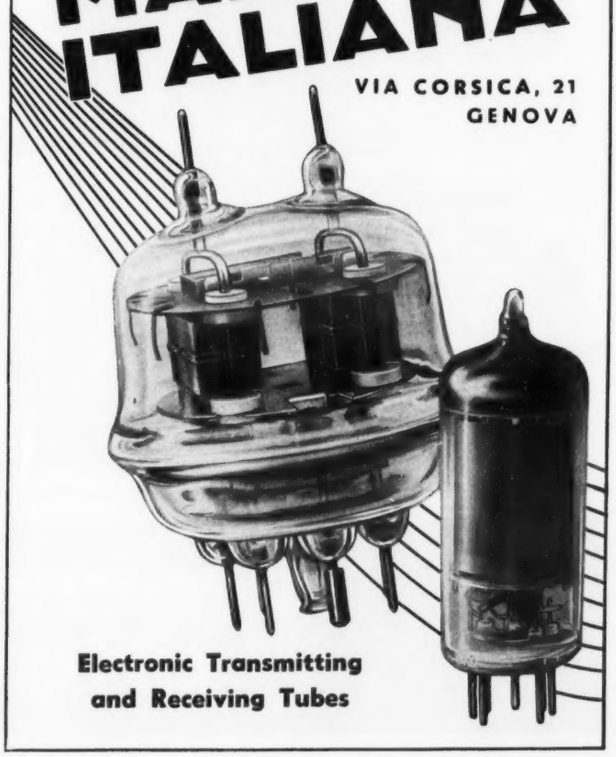

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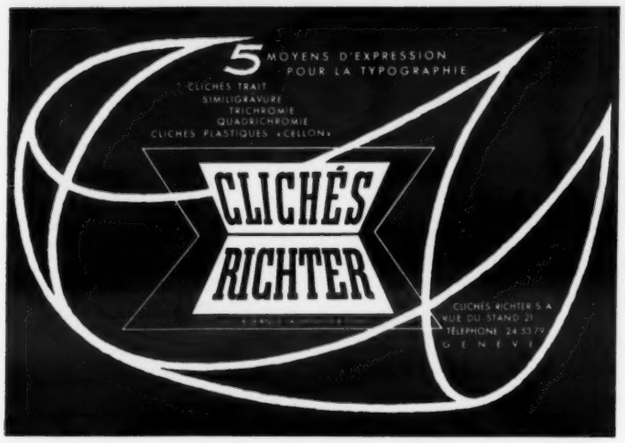

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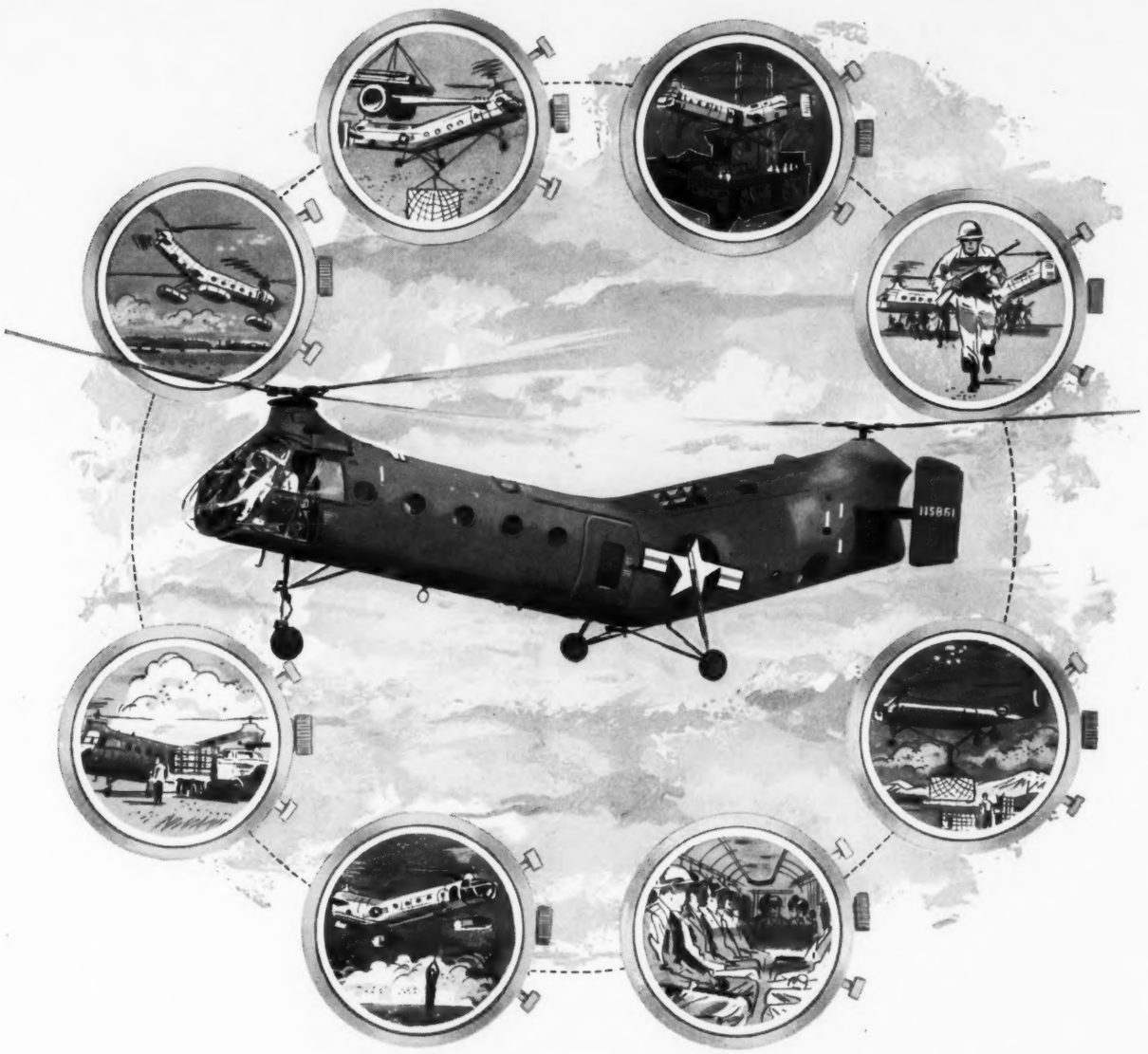

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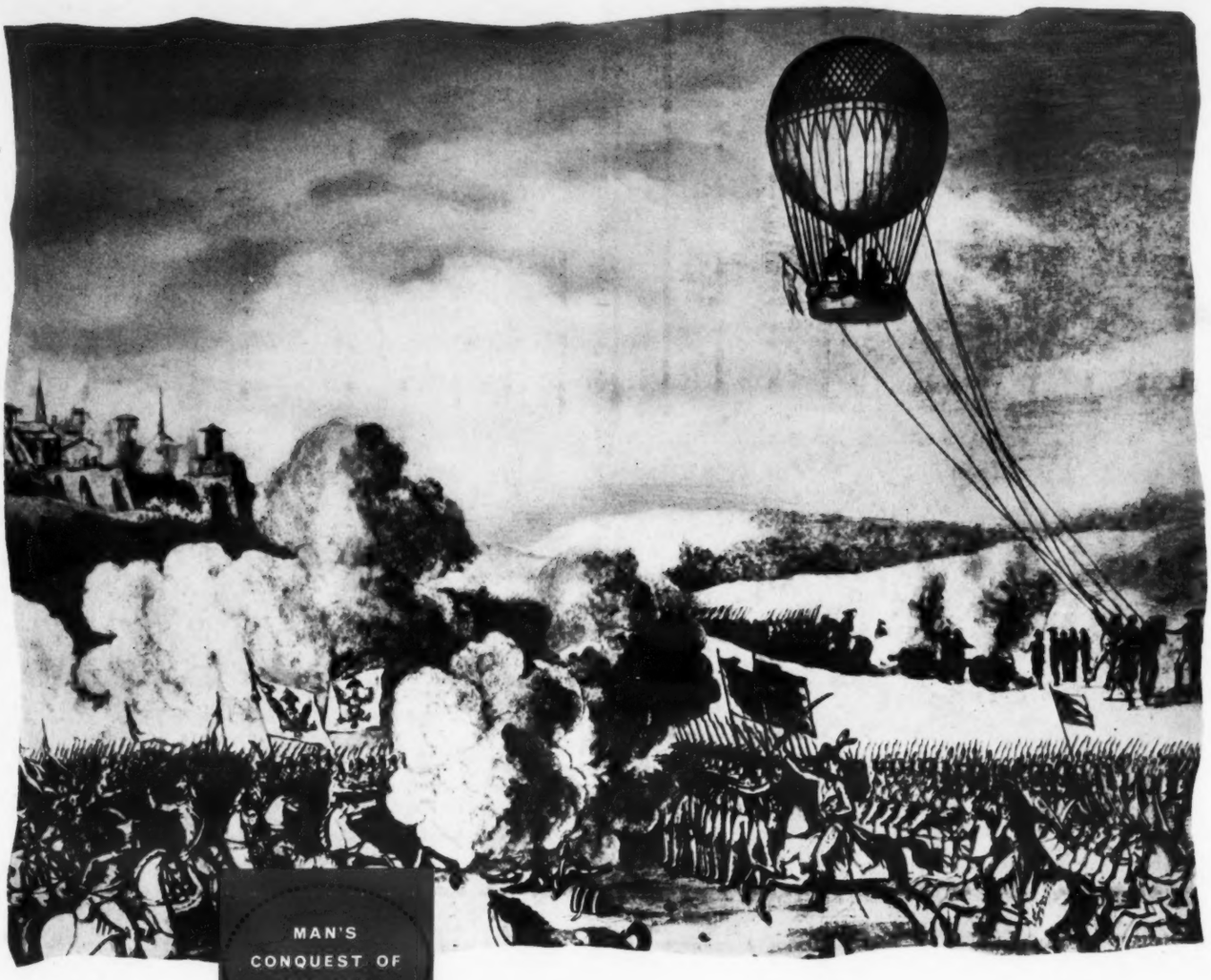

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First aerial observation of battle

Undoubtedly an important factor in the victory of the French forces at the Battle of Fleurus in Belgium in 1794 was, believe it or not, aerial reconnaissance. For in this battle Captain J. M. J. Coutelle, later promoted "Captain of Napoleon's Aerostiers", became the world's first military balloon observer. For hours Coutelle's balloon hovered over "no man's land" and even over the enemy's lines. With signal flags he and a companion relayed vital information back to the French Army Commander.

Coutelle continued his aerial reconnaissance for Napoleon at Mayence in 1796 and elsewhere. But in Egypt, where he had been ordered in 1798, his balloon equipment was finally destroyed in a naval battle.

Man's conquest of the air has come a long way from the uncontrollable balloons of yesterday to the sleek, earth-circling giants of today. Since the advent of powered flight, Esso research has helped speed the progress of aviation by creating new and improved fuels and lubricants for military and commercial aircraft.

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